SAMPLING AND ANALYSIS PLAN

WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

JUNE 2000
REF. NO. 15670 (2)
This report is printed on recycled paper.

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1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) supports the U.S. Environmental Protection Agency (U.S. EPA)-approved Pilot Project Work Plan (Work Plan) developed by NewFields Inc. (dated May 23, 2000) for the Waukegan Manufactured Gas and Coke Plant (WCP) located in Waukegan, Illinois. The Work Plan was developed by NewField, Inc. on behalf of the WCP Group to address the requirements contained in the Record of Decision (ROD) issued for the WCP Site in September 1999. Conestoga-Rovers & Associates (CRA) was retained by the WCP Group to implement the scope of work identified in the Work Plan.

In addition to the Work Plan and SAP, several other documents have been prepared to assist in the overall goal of successfully completing the Pilot Project Study, including:

- Health and Safety Plan,
- Quality Assurance Project Plan, and
- Treatability Protocols.

The SAP addresses the sampling requirements of the following sections of the Work Plan:

Section 4 - Study Area Characterization,

Section 5 - Pilot Extraction and Reinjection Units,

Section 6 - Bench-Scale Groundwater Treatment Assessment, and

Section 7 - Pilot Project Data Analysis Goals.

The SAP supplements the Quality Assurance Project Plan (QAPP) and addresses all sample and field data collection activities. The SAP specifies the sample collection schedules, equipment, and personnel, and includes a Site Plan showing the proposed Pilot Project layout. The SAP includes a description of monitoring equipment, sampling, and laboratory testing, including:

- description of sampling tasks;
- description of required data collection and laboratory tests,;
- required quality assurance and quality control;
- schedule of monitoring frequency;
- identification of monitoring equipment;

- installation of monitoring components; and
- maintenance of site equipment.

The SAP also includes recording and reporting mechanism requirements, including:

- daily operating logs, including the field log book;
- laboratory records;
- mechanisms for reporting emergencies or operational difficulties; and
- personnel and maintenance records.

2.0 PROJECT DESCRIPTION

2.1 SITE OVERVIEW

The WCP Site is located in Waukegan, Illinois, on the peninsula separating Waukegan Harbor from Lake Michigan (Figure 2.1). The property and its environs have been part of the industrial/commercial waterfront in Waukegan. The sand dunes and beach area adjacent to the WCP Site are used for public recreation. Figure 2.2 provides a plan view of the WCP Site.

The WCP Site is underlain by near-surface fill materials that were placed over a fine-grained sand unit. The sand unit extends from the ground surface to the top of a low-permeability clayey till unit. The shallow groundwater occurs in a 30-foot thick fine sand unit. Shallow groundwater flows in response to infiltration on the peninsula, discharging to the surrounding surface water. The vadose zone soil and the deep portion of the shallow aquifer at the WCP Site have been adversely impacted due to past activities. Soil at the WCP Site is contaminated with coal tar and arsenic. The groundwater is mainly contaminated with arsenic, phenols, and ammonia. The impacted portion of the shallow aquifer is found in the lowest 5 feet of the sand unit, approximately 25 feet below ground surface.

2.2 PILOT PROJECT OVERVIEW

As stated in the ROD, the selected groundwater remedy is a mobile, cell-based, low-flow extraction/treatment/reinjection system. The ROD groundwater remedial objectives are divided into two phases, as short-term (Phase 1) and long-term (Phase 2) goals. The short-term goal is a substantial reduction of contaminants at the deep portion of the shallow aquifer in order to remove the chemical inhibitors of natural attenuation, and minimize impacts of contaminated groundwater on Lake Michigan and harbor surface water. Subsequently in Phase 2, the long-term remedial goals are pursued based on Monitored Natural Attenuation. As noted in the ROD: *"Once the inhibitive concentrations of contaminants have been removed and the nitrate source and oxygenation from treatment re-injection is available in the aquifer, degradation should occur."* In the long-term, attainment of maximum concentration limits (MCLs) is anticipated. The objective of the mobile, cell-based, low-flow extraction/treatment/reinjection system is to reduce the concentration of chemical inhibitors to allow natural attenuation to reduce the concentrations of other groundwater contaminants.

The ROD states that the design of the Phase 1 groundwater remedy will be based in part on pilot testing of a groundwater extraction and reinjection system. The approved Pilot Project includes the installation, operation and monitoring of two low-flow, cell-based test units as described herein. This Pilot Project SAP was prepared to address the work scope summarized in the Work Plan for pilot testing of the low-flow, cell-based groundwater extraction and reinjection systems developed by NewFields, Inc. The approved Work Plan prepared by NewFields, Inc. is dated May 23, 2000. CRA was retained by the WCP Group to implement the Pilot Project.

The Pilot Project includes several data collecting tasks, which will be implemented to determine design parameters and constraints for implementation, operation, and performance measurement of the extraction/re-injection unit of the ROD groundwater remedy. These data collecting activities consist of the following:

1. study area characterization
2. installation and operation of a constant low -flow extraction/re-injection unit;
3. installation and operation intermittent (pulse) low-flow extraction unit;
4. post-test monitoring;
5. treatability and bench scale testing, and
6. evaluation of the collected data.

This SAP has been developed to guide the implementation of these data collecting activities to ensure that the data collecting objectives are met. The following sections detail the procedures to be used during these data collecting activities.

3.0 GENERAL FIELD PROTOCOLS

3.1 OVERVIEW

General protocols applicable to a number of field activities to be completed under this Pilot Project are summarized herein.

3.2 DECONTAMINATION PROCEDURES

3.2.1 DRILLING EQUIPMENT

Upon mobilization of the drill rig, Geoprobe, or cone penetrometer test rig to the Site and prior to subsurface explorations, the equipment will be thoroughly steam-cleaned to remove oil, grease, mud, and other foreign matter. Before explorations at each subsequent testing location, the augers, cutting bits, probes, samplers, drill steel, and associated equipment will be decontaminated to prevent cross contamination from the previous drilling activities. Equipment decontamination will be accomplished by flushing and wiping the components to remove all visible sediments followed by:

i) steam-cleaning and/or high pressure washing with potable water to remove particulate matter and surface films; and
ii) rinsing thoroughly with potable water.

A decontamination pad will be constructed for cleaning of drilling rigs and other equipment. The decontamination pad will facilitate capture of cleaning fluids for proper management. Figure 3.1 depicts the layout and construction of the decontamination pad. Collected decontamination fluids will be managed as described in Section 3.4.

3.2.2 SAMPLING EQUIPMENT

Sampling equipment will be decontaminated prior to field use and after each sample is collected to prevent cross-contamination between samples. Whenever practicable, dedicated sampling equipment will be used to minimize the potential for sample cross contamination. Dedicated sampling equipment will be cleaned prior to initial use and following the completion of the Pilot Project.

Decontamination of equipment used for collection of samples for laboratory analyses will be performed as follows:

i) wash with potable water and Alconox^{tm}, Liquinox^{tm} or similar low-phosphate detergent using a brush, if necessary, to remove all visible foreign matter;
ii) rinse thoroughly with potable water;
iii) rinse thoroughly with distilled water; and
iv) allow the equipment to air dry on a clean plastic sheet as long as possible.

Following the final rinse, equipment will be visually inspected to verify that it is free of soil particulates and other solid material that could contribute to possible sample cross-contamination.

Similarly, well casings and screens for monitoring wells, extraction wells and reinjection wells will be thoroughly cleaned prior to use using the following procedure:

i) steam-cleaning and/or high pressure washing with potable water to remove particulate matter and surface films;
ii) rinse thoroughly with potable water; and
iii) air dry as long as possible and wrap in clean plastic sheeting for delivery to installation site.

Fluids used for cleaning will not be recycled. Decontamination fluids will be managed as described in Section 3.4.

3.3 FIELD LOG DOCUMENTATION

The field logbook will be a bound document with consecutively numbered pages. The entries for each day will commence on a new page, which will be dated. All entries will be made only in indelible ink. Corrections will be made by marking through the error with a single line, to remain legible, and initialing this action followed by writing the correction. The person making the entries in the logbook will sign or initial each page of entries as they are completed.

The field logbooks generated will be numbered consecutively and maintained by one of CRA's Site representatives. Upon completion of the fieldwork or during periods when fieldwork is not scheduled, the field logbooks will be maintained in CRA's Chicago office. Ultimately, after completion of all stages of fieldwork, the logbooks will be maintained in the document file in CRA's Chicago, Illinois office.

The following information will be recorded in the field logbook for each sample collected:

i) Site location identification;
ii) unique sample identification number;
iii) date and time (in 2400-hour time format) of sample collection;
iv) weather conditions;
v) designation as to the type of sample (groundwater, soil, etc.);
vi) designation as to the means of collection (grab, bailer, etc.);
vii) name of sampler;
viii) analyses to be performed on sample;
ix) any other relevant comments such as odor, staining, texture, filtering, preservation, etc.; and
x) sample location.

Records of equipment maintenance and calibration, and observations on equipment performance will also be recorded in the field logbook. Alternatively, CRA may utilize standard forms to record information such as stratigraphy, well construction and well development.

3.4 WASTE HANDLING PROTOCOLS

Wastes generated during the investigation will include general refuse, soil cuttings from soil borings and monitoring wells, decontamination fluids, extracted groundwater, drilling fluids, and monitoring well purging fluids. General refuse, including plastic sheeting, buckets, paper bags, etc. will be disposed of in the waste receptacles. Daily refuse and personal protective equipment (PPE) will be collected in plastic bags and disposed of as necessary to keep the Pilot Project area neat. Soil cuttings from monitoring, extraction, and reinjection well installations will be placed into 55-gallon drums and staged in the remedial investigation drum storage area (see Figure 2.2) or in a separate area designated by the WCP Group.

Decontamination and well development fluids will be staged in 55-gallon drums or polyethylene tanks near the generation site. Following completion of the Pilot Project, these fluids will be transferred into one of three holding tanks that will be brought to the Site during this Pilot Project.

4.0 STUDY AREA CHARACTERIZATION

4.1 OVERVIEW

As documented in the approved Work Plan, the following tasks will be completed to characterize the study area.

1. Two direct-push vertical geophysical profiles will be advanced using cone penetrometry to identify stratigraphy and to estimate the vertical extent of the impacted portion of the shallow aquifer.
2. Groundwater samples will be collected from nested monitoring wells installed in the Extraction/Reinjection Unit (E/R Unit) and at one monitoring well nest associated with the Extraction Unit (E Unit).

Further detail concerning each of these tasks is provided in the following sections.

4.2 CONE PENETROMETER TESTING

Two direct-push geophysical profiles will be obtained using cone penetrometer testing (CPT) with simultaneous measurement of electrical conductivity (CPT/EC) and ultraviolet fluorescence (CPT/UVF) during each push. CPT/UVF will be used in lieu of gas chromatography (CPT/GC) due to the lack of commercial availability of the CPT/GC technology. The selected locations for CPT/UVF testing will be near the location of the central extraction well in the E/R Unit and near the extraction well in the E Unit. This will allow visual confirmation of CPT data with soil samples obtained during advancement of the extraction well boreholes. In case of sensor failure, every reasonable effort will be made to repair the unit. However, if replacement parts are not readily available or repairs cannot be made in a timely fashion, the Pilot Project data collection activities will proceed ahead without the affected equipment.

Standard operating procedures for CPT/UVF/EC testing obtained from the selected contractor, Stratigraphics, are provided in Appendix A.

4.2.1 CONE PENETROMETRY

CPT consists of using a truck-mounted rig to advance a small diameter (1.7 inch) instrument probe (penetrometer) into the ground while a computer data acquisition system records telemetry received during advancement of the penetrometer.

Measurements of the resistance to penetration acting on the probe and friction along the sides of the probe are measured by pressure transducers while the probe is advanced through the subsurface soils. The resistance of the soil to penetration (cone-end bearing or tip resistance) and sliding friction along the walls of the penetrometer are used to identify the subsurface stratigraphy. The cone end-bearing pressures are much higher in sands than in clays. The ratio of friction to cone end-bearing resistance (termed friction ratio) is high in clays and low in sands. These two parameters are interpreted to determine the stratigraphy.

CPT soundings will be advanced through the upper sand unit and approximately three feet into the underlying clay till unit or until CPT refusal is obtained. The boreholes resulting from the CPT soundings will be grouted to the surface with a bentonite slurry simultaneously as the probe is withdrawn from the ground.

4.2.2 CPT/EC TESTING

In addition to obtaining pressure measurements, soil electrical conductivity measurements will be recorded at all testing locations. CPT/EC measurements consist of an electrode array mounted on the CPT probe, which measures soil electrical conductivity. The high chloride and ammonia concentrations that are present in the lower portion of the upper sand unit should be detectable using CPT/EC and therefore, may be useful for development of a vertical profile of groundwater contamination. EC measurements can be obtained simultaneously with CPT measurements.

4.2.3 CPT/UVF TESTING

The UVF module consists of a sapphire window in the side of the penetrometer, an ultraviolet (UV) light source, filters, and photonic sensors. The UV light source illuminates the soil next to the window. Certain organic compounds that may be present in the subsurface may fluoresce in the presence of an UV light source if present at high enough concentrations. The resulting light can be detected by the photonic sensors. The intensity of the fluorescence can often be related to the concentration of contamination in the soil. UVF measurements can be obtained simultaneously with CPT and EC measurements.

4.3 CONSTRUCTION OF PILOT UNITS

4.3.1 OVERVIEW

Two test units, the E/R and E Units, will be constructed and operated during this Pilot Project. Construction of these units requires the installation of a number of injection wells, extraction wells and multi-level groundwater monitoring wells. A brief description of each system is provided below. Protocols for the installation and development of these wells are provided in the following section. The proposed location of the E/R and E Units is depicted in Figure 2.2.

Extraction/Reinjection Unit (E/R Unit)

The E/R Unit will be comprised of three extraction wells and six reinjection wells. This unit is intended to simulate the simultaneous operation of low-flow extraction and reinjection wells. In such units, the outer reinjection wells are intended to supply flushing water that may enhance the removal efficiency of the inner extraction wells. The E/R Unit will be operated at a constant extraction rate for the duration of the Pilot Project. Figure 4.1 depicts the configuration of extraction wells, reinjection wells and groundwater monitoring wells in the E/R Unit.

Extraction Unit (E Unit)

The E Unit will be comprised of a single extraction well, which will be operated under both steady state and pulse conditions with up to three different extraction rates. The removal efficiency of the extraction well will be evaluated under constant versus intermittent (pulse) operation, as well as different extraction rates. Figure 4.2 depicts the configuration of the extraction well and groundwater monitoring wells in the E Unit.

4.3.2 EXTRACTION AND REINJECTION WELL INSTALLATION

The boreholes for the extraction/reinjection wells will be advanced approximately one foot into the top of the glacial till unit, present at a depth of approximately 30 feet below ground surface. Boreholes will be advanced using a rotary drill rig equipped with 4.25-inch inside diameter hollow stem augers. The extraction and reinjection wells will be constructed such that the bases of the well screens are placed slightly below the glacial till interface.

Specific installation protocols for the extraction/reinjection wells are described below:

i) Prior to set up at the borehole location, all drilling and equipment and well construction materials will be decontaminated prior to use as discussed in Section 3.2.

ii) The borehole will be advanced to the target depth using 4.25-inch inside diameter hollow-stem augers.

iii) A nominal 2-inch diameter (No. 10 slot) polyvinyl chloride (PVC) well screen, five feet in length, attached to a sufficient length of 2-inch diameter schedule 40 PVC riser pipe to extend to approximately 2 feet above the ground surface will be placed into the borehole through the augers.

v) A filter sand pack consisting of No. 30 silica sand will be installed to a minimum height of two feet above the top of the well screen as the augers are removed. If heaving sands are encountered, the filter pack may be constructed of a natural sand pack.

vi) A minimum two-foot thick seal consisting of 3/8-inch bentonite pellets will be placed on top of the sand pack and hydrated using potable water (if needed).

vii) The remaining borehole annulus will be sealed to within two feet of the surface using bentonite chips that will be hydrated using potable water.

viii) The upper two feet of the annulus will be filled with drill cuttings.

ix) The well head will be fitted with a water-tight, lockable cap.

Split-spoon samples will be collected continuously during advancement of the borehole for Extraction Well No. 1 (EW-1) in the E/R Unit and EW-4 in the E Unit. However, if heaving sands prevent the continuous collection of these split-spoon samples at depth, the augers will be retracted and the borehole will be advanced to the target depth with a plug installed in the base of the hollow stem auger. This information will be used to confirm stratigraphic information obtained from the CPT soundings. Soil samples will be described by a geologist in accordance with the Unified Soil Classification System (USCS).

Extraction and reinjection well construction detail is presented in Figure 4.3.

4.3.3 MONITORING WELLS

Two monitoring well nests, each consisting of a cluster of five monitoring wells, will be installed in the E/R Unit. One monitoring well nest consisting of a cluster of five monitoring wells will be installed in the E Unit. System layouts for the E/R Unit and the E Unit are illustrated in Figures 4.1 and 4.2, respectively. Monitoring well nests will be installed using hollow-stem auger drilling methods. The spacing between the screened intervals of the clustered wells in the E/R Unit and the E Unit is illustrated on cross-sectional views provided in Figures 4.1 and 4.2, respectively.

Monitoring well clusters will be constructed at the surface using precleaned well materials (see Section 3.2.2). Each individual monitoring well will be constructed of ½-inch or ¾-inch nominal diameter PVC well materials attached to 12-inch lengths of No. 10 slot PVC well screen. The monitoring well screens will be wrapped in filter cloth prior to installation to minimize the intrusion of silt into the well annulus. Well materials will be assembled at the surface prior to lowering the clustered wells into the boreholes. The well clusters will be held together using nylon or plastic straps to keep the cluster assembly together during installation into the borehole.

Clustered groundwater monitoring wells will be installed using the following procedures.

i) Prior to set up at the borehole location, all drilling and equipment and well construction materials will be decontaminated prior to use as discussed in Section 3.2.

ii) The borehole will be advanced to the target depth using 6.25-inch inside diameter hollow-stem augers. The lead auger will be fitted with an expendable knockout plug to prevent the entry of sand.

iii) The borehole will be advanced approximately one foot into the glacial till formation and, if necessary, potable water will be added to the augers to minimize sand heave. The geologist will record the volume of water added to the augers. The knockout plug will then be pushed off the bottom of the lead auger.

iii) The well cluster will then be inserted into the augers such that the deepest monitoring well rests at the glacial till/upper sand unit interface. Filter sand may be added to the base of the borehole to ensure proper setting of the deep well. Individual well pipes will be labeled to avoid possible confusion between nested monitoring wells. Well cluster pipes will be labeled with the letters "A, B, C, D and E" designating the shallowest to the deepest well in the cluster.

v) A filter sand pack consisting of No. 30 silica sand will be installed to a height of two feet above the top of the uppermost well screen as the augers are removed. (Note: If heaving sand is conditions are present, this may result in the inclusion of native sand materials within the sand pack).

vi) The remaining borehole annulus will be sealed to the surface using a bentonite grout mixture.

viii) Each well head will be fitted with a watertight cap.

4.3.4 WELL DEVELOPMENT

In order to establish good hydraulic communication with the aquifer and reduce the volume of sediment in the monitoring, extraction, and reinjection wells, well development will be conducted in accordance with the procedures outlined below.

i) The well will be surged using a precleaned surge block or bailer for a period of at least ten minutes.

ii) Water will be purged from the well using a precleaned electronic or pneumatic submersible pump, peristaltic pump, or hand operated pump. Purged water will be managed as described in Section 3.4.

iii) Groundwater will be collected at regular intervals and the pH, temperature, turbidity, and conductivity will be measured using field instruments. These instruments will be calibrated daily according to the manufacturer's specifications. Additionally, observations such as color, odor, and clarity of the purged water will be recorded.

iv) Development will continue until the turbidity and silt content of the monitoring wells are reduced to the extent practicable and three consistent readings of pH, temperature, and conductivity are recorded, or a maximum of ten well volumes are purged as calculated below:

$$V_p = 10(\pi r^2 H)$$

where:
V_p = purge volume
H = height of the water column in the well
r = radius of the well in feet

v) Well development will be considered complete when three consecutive readings are within ±0.5 standard units for pH, within ±0.5° (Fahrenheit or Celsius) for temperature, and within ±10 percent for conductivity.

vi) Total well depths will be measured and recorded following well development.

Well development water will be managed as described in Section 3.4.

4.4 PILOT PROJECT PRE-EXTRACTION GROUNDWATER MONITORING

Prior to the initiation of the Pilot Project, groundwater samples will be collected from the monitoring wells installed in the E/R Unit and the E Unit. Groundwater sampling will be performed no sooner than 48 hours following the completion of well development activities described in the previous section and will be completed within 24 hours of the startup of groundwater extraction or extraction/injection in the pilot units.

Groundwater samples will be collected from the monitoring wells in accordance with the following protocols:

i) A new pair of disposable nitrile gloves will be used for each sample.

ii) The depth to water in each well will be measured to the nearest 0.01 foot using an electronic water level meter. The measuring device will be decontaminated prior to use following the cleaning sequence provided in Section 3.2.2.

iii) Prior to sampling, each well will be purged using a dedicated section of polyethylene tubing and a peristaltic pump. Purge rates will be kept below one Liter per minute to ensure turbidity is minimized.

iv) Field measurements of pH, conductivity, oxidation-reduction potential (ORP), dissolved oxygen (DO), turbidity, and temperature of the water will be obtained during the purging of each well. Field instruments will be calibrated in accordance with manufacturer's specifications. Purging will be considered complete when three consecutive readings are within ±0.5 standard units for pH, within ±0.5° (Fahrenheit or Celsius) for temperature, and within ±10 percent for conductivity or a maximum of three well volumes are purged.

v) After purging the required volume, groundwater samples will be collected. Containers will be filled using techniques that minimize sample agitation. Groundwater samples will be collected from the equipment used to purge the monitoring well as described above. Groundwater samples will be collected in order of decreasing analyte volatility.

vi) Samples will be labeled with a unique sample identification number (see Section 7.2.1) and placed into an iced cooler, pending delivery to the project laboratory.

Pre-extraction groundwater samples will be analyzed for the analytes summarized in Table 4.1. Quality control (QC) samples to be collected during pre-extraction monitoring events include field duplicates, equipment blank samples and matrix spike/matrix spike duplicate samples. QC samples will be collected at the frequency specified in the QAPP. A trip blank will be provided by the laboratory for each sample cooler containing multiple aqueous samples for target compound list (TCL) volatile organic compounds (VOC) analysis. Trip blanks will be analyzed for TCL VOCs.

Groundwater samples also will be collected during operation of the E/R Unit and the E Unit. This groundwater sampling is discussed in Section 5.0, which deals with operation of the pilot units.

5.0 OPERATION OF PILOT UNITS

5.1 OPERATION OVERVIEW

In accordance with the approved Work Plan, the E/R Unit will be pumped at a constant low-flow rate of approximately 0.9 gallons per minute (gpm) (i.e., 0.3 gpm from each extraction well) for a period of approximately 4 weeks. Simultaneous with groundwater extraction, tap water will be injected into the reinjection wells at a rate of 0.9 gpm (i.e., 0.15 gpm into each reinjection well). These flow rates may be adjusted prior to the initiation of the Pilot Project depending upon Site conditions. At the initiation of the operation of the E/R Unit, a bromide tracer will be injected.

The E Unit will undergo an intermittent extraction schedule with the pump on for 7 days and then off for 7 days. Four cycles are contemplated for the pilot testing. The extraction rate from the E Unit will be reduced with each successive pumping cycle, starting at 0.8 gpm and ending at 0.2 gpm. These flow rates may be adjusted prior to the startup of the Pilot Project depending upon Site conditions. A bromide tracer test will not be conducted at the E-unit location.

The extracted water from both units will be stored in three 20,000-gallon equalization tanks. These tanks will be used to provide short-term storage for the extracted groundwater during the Pilot Project.

5.2 E/R UNIT OPERATION

The E/R Unit will consist of three extraction wells, six reinjection wells, two monitoring well nests, and one single monitoring well (see Figure 4.1). The E/R Unit will be operated for 28 days as described in Section 5.2 of the Work Plan.

5.2.1 GROUNDWATER EXTRACTION

The extraction wells will be pumped at a constant low-flow combined rate of approximately 0.9 gpm (i.e., 0.3 gpm from each extraction well). The extraction wells will be pumped using peristaltic pumps and long-life tubing that discharge through in-line flow meters. Peristaltic pumps will be Masterflex LS® or similar variable-speed, modular drive pumps, equipped with up to two modular drives per controller, capable of sustained flow rates within the desired range.

Each discharge line will be equipped with a direct-reading inline flow meter (Gilmont® Model 03230-14, or similar) capable of reading liquid flows in the range of 20 milliliters per minute (ml/min) to 1,800 ml/min (5.3×10^{-3} to 0.48 gpm). The accuracy of the in-line flow meters will be verified with bucket and stopwatch measurements. Discharge water will be directed to an intermediate storage tank where it will then be pumped to the 20,000-gallon storage tanks.

An enclosure will be constructed in close proximity to the E/R Unit to house the peristaltic pumps, controllers and flow meters. This enclosure will serve to protect this equipment during inclement weather. Figure 5.1 depicts the E/R Unit groundwater extraction system layout.

5.2.2 GROUNDWATER REINJECTION

Tap water will be injected into each of the six reinjection wells that comprise the E/R Unit at a rate of approximately 0.15 gpm (0.9 gpm total injection rate). Reinjection water will be staged on Site in a 1,500-gallon capacity tank that will be filled daily with tap water from a nearby source. Tap water will be pumped into each reinjection well using peristaltic pumps, long-life tubing and in-line flow meters as described in the previous section.

An enclosure will be constructed in close proximity to the E/R Unit to house peristaltic pumps, controllers and flow meters. This enclosure will serve to protect this equipment during inclement weather. Figure 5.2 depicts the E/R Unit groundwater injection system layout.

5.2.3 TRACER TEST

A bromide tracer test will be conducted during the constant low-flow extraction/reinjection portion of the Pilot Project program at the E/R Unit. A bromide tracer test will not be conducted at the E Unit location. The use of an anionic tracer such as bromide is considered appropriate for this project for two reasons. First, bromide is considered a "conservative" tracer (one which travels at nearly the same velocity as groundwater). Second, bromide is not expected to be present in the groundwater at any appreciable concentration. In order to evaluate the natural bromide concentrations prior to the tracer test, bromide analyses will be performed at the tracer test injection well, the extraction wells in the E/R Unit prior to startup.

The bromide tracer test will be injected immediately prior to the startup of the E/R Unit. The bromide will be added to the tap water injected into the central reinjection well that is closest to Monitoring Well Nest No. 1 (reinjection well RW-2 shown in Figure 4.1). The bromide tracer will be introduced to RW-2 using the following procedure.

i) The bromide tracer consisting of approximately 200 grams of potassium bromide will be mixed with 0.3 Liters of deionized water to produce a solution containing a minimum initial concentration of 500,000 milligrams per Liter (mg/L).

ii) The bromide tracer solution will be injected into the extraction well immediately prior to (i.e. no sooner than 2 hours before) the initiation of the Pilot Test in the E/R Unit.

iii) The bromide tracer will be injected into RW-2 using a peristaltic pump at a flow rate not exceeding 0.5 ml/min to minimize agitation of the injection well. The injection tube will be moved up and down through the screened interval of RW-2 to allow mixing and a more equal distribution of tracer in the screened interval.

iv) Following injection of the tracer solution, the solution will be allowed to equilibrate in RW-2 for a period of approximately 30 minutes.

v) Following that interval and prior to the startup of the pilot test in the E/R Unit, a groundwater sample will be collected from RW-2 for bromide analysis to obtain the initial concentration of the tracer in the reinjection well.

vi) Purging of RW-2 will not be conducted prior to collection of this sample to minimize removal of tracer from the well.

5.2.4 E/R UNIT MONITORING

The groundwater monitoring wells in both of the monitoring well nests installed in the E/R Unit will be sampled at regular intervals during operation of the E/R Unit. Sampling of the water purged from each extraction well of the E/R Unit also will be conducted three times per week. Water levels within the E/R unit will be monitored daily.

Water samples will be collected at the frequencies and for the analytes summarized in Table 4.1. Pilot Project sampling protocols are summarized in Section 5.4.

5.3 E UNIT OPERATION

The E Unit will consist of one extraction well and one monitoring well nest (see Figure 4.2). This unit will be operated under both steady state and pulse conditions, with up to three different extraction rates.

5.3.1 GROUNDWATER EXTRACTION

The E Unit will be operated on the schedule defined in Section 5.2 of the Work Plan. This schedule consists of four 7-day extraction cycles, each of which is followed by a 7-day off cycle. Groundwater will be pumped at different rates during each successive extraction cycle. The first extraction cycle will consist of groundwater extraction at a rate of 0.8 gpm. The pumping rate during each of the three successive extraction cycles will be reduced by 0.2 gpm (i.e., 0.6 gpm during the second extraction cycle, 0.4 gpm during the third extraction cycle and 0.2 gpm during the fourth and final cycle). The extraction well will be pumped with a peristaltic pump using new long-life tubing discharged through an in-line flow meter. The in-line flow meter readings will be confirmed with measured bucket and stopwatch measurements. Water discharge will be to an intermediate storage tank that will be periodically pumped to large storage tanks in a cycle based on sump level.

Peristaltic pumps will be Masterflex LS® or similar variable-speed, modular drive pumps, equipped with up to two modular drives per controller, capable of sustained flow rates in the desired range. Each discharge line will be equipped with a direct-reading inline flow meter (Gilmont® Model 03230-15, or similar) capable of reading liquid flows in the range of 60 ml/min to 4,100 ml/min (1.5 x 10^{-2} to 1.1 gpm).

An enclosure will be constructed in close proximity to the E Unit to house the peristaltic pumps, controllers and flow meter. This enclosure will serve to protect this equipment during inclement weather. Figure 4.1 depicts the E Unit groundwater extraction system layout.

5.3.2 E UNIT MONITORING

The groundwater monitoring wells in the WN-3 monitoring well nest installed in the E Unit will be sampled three times a week during E Unit operation. At least one groundwater sampling event each week will be conducted on the same day that the pump operational mode is changed (i.e., pumping started or stopped). One groundwater sampling event will also be conducted during the midpoint of each extraction cycle. Sampling of the water purged from the E Unit extraction well will be conducted three times per week. Water levels within the E-unit wells will be monitored daily.

Water samples will be collected at the frequencies and for the analytes summarized in Table 4.1. Pilot Project sampling protocols are summarized in Section 5.4.

5.4 PILOT PROJECT SAMPLING PROTOCOLS

5.4.1 MONITORING WELLS

Groundwater samples will be collected from the monitoring wells during the Pilot Project in accordance with the protocols detailed in Section 4.4, except that purging of the monitoring wells prior to sampling will not be necessary while groundwater extraction is occurring in the test cells. In accordance with the approved Work Plan, QC samples will not be collected during operation of the E/R and E Units. QC samples will only be collected during the pre-test and post-test monitoring described in Sections 4.4 and 5.4.6, respectively.

5.4.2 TAP WATER TESTING

Tap water injected into the reinjection wells of the E/R Unit will be analyzed three times per week for residual chlorine, pH and dissolved oxygen. Dissolved oxygen and pH will be determined by inserting direct-reading field instruments into the tap water holding tank. Field instruments will be calibrated in accordance with manufacturer's specifications. Residual chlorine will be measured in the field using chlorine test paper. The test paper will be dipped into the tap water holding tank and compared to a color-coded chart to obtain the residual chlorine concentration. Residual chlorine, pH and dissolved oxygen data will be recorded in the field logbook.

5.4.3 TRACER TEST

Bromide tracer sampling of the monitoring wells within the E/R Unit will be conducted as specified in Table 4.1. The E/R Unit will be sampled daily for bromide for a period of 7 days. Bromide sampling will then shift to three times per week for the remainder of the E/R Unit test.

Groundwater samples will be collected from the monitoring wells for bromide analysis during the Pilot Project in accordance with the protocols detailed in Section 4.4. Samples from groundwater extraction and reinjection wells will be collected in accordance with the protocols summarized below. QC samples will not be collected for bromide analysis during operation of the E/R and E Units.

5.4.4 EXTRACTED GROUNDWATER

Sampling of the water purged groundwater from the extraction wells in the E/R and E Units will be performed during the Pilot Study. Table 4.1 of this SAP provides a summary of the frequency and analytical parameters for the sampling program. Groundwater samples will be collected from the extraction wells in accordance with the following protocols.

i) A new pair of disposable nitrile gloves will be used for each sample.

ii) Purged groundwater samples will be collected from the discharge tube of the peristaltic pump being used to extract water from the well during the Pilot Project. During pre-test, post-test, and during the shut down period of the E Unit, the extraction well samples will be collected in accordance with the protocols outlined in Section 4.4. However, purging of the extraction wells prior to collection of groundwater samples will not be required if samples are collected during a period when groundwater extraction is occurring.

iii) Containers will be filled using techniques, which minimize sample agitation. Groundwater samples will be collected from the equipment used to purge the monitoring well as described above. Groundwater samples will be collected in order of decreasing analyte volatility.

iv) Samples will be supplied with a unique sample identification number and placed into an iced cooler, pending delivery to the project laboratory (see Section 7.2.1).

5.4.5 REAL-TIME MONITORING

Specific conductance of the effluent from the central extraction well of the E/R Unit and the extraction well of the E Unit will be monitored for specific conductance continuously monitored during the Pilot Project. To accomplish this task, the central extraction well in the E/R and E Units will be equipped with a downhole data logger/pressure transducer (10 psi or less) capable of measuring hydraulic pressure and specific conductance. This equipment will be programmed to obtain readings at one-hour intervals. These data will be downloaded to a computer for evaluation following the test. Backup readings of specific conductance will be recorded daily with field instrumentation.

5.4.6 PILOT PROJECT POST-EXTRACTION MONITORING

The monitoring wells within the E/R and E Units will be sampled twice, at one week and four weeks following the shutdown of each test cell to assess the rate of recovery of contaminants. The sampled groundwater will be analyzed for parameters identified in Table 4.1.

Groundwater samples will be collected from the extraction wells in accordance with the protocols detailed in Section 4.4. QC samples to be collected during post-extraction monitoring events include field duplicates, equipment blank samples and matrix spike/matrix spike duplicate samples. QC samples will be collected at the frequency specified in the QAPP. A trip blank will be provided by the laboratory for each sample cooler containing multiple aqueous samples for VOC analysis. Trip blanks will be analyzed for VOCs.

5.5 FIELD DATA

During the implementation of the Pilot Project, various field measurements will need to be taken and recorded. The following sections outline the procedures that will be used to take and record the measurements.

5.5.1 WEATHER CONDITIONS

Weather conditions may affect the results of the Pilot Project and therefore will be recorded at least once per day during the Pilot Project. Data on weather conditions including temperature, barometric pressure, wind speed and direction, precipitation and relative humidity will be obtained from the adjacent OMC's facility weather station or the National Weather Service for the Waukegan area. In addition, a rain gauge will be maintained at the Site and daily measurements will be recorded. Weather information will be recorded in the field logbook.

5.5.2 HYDRAULIC MONITORING

A round of groundwater measurements will be recorded prior to the installation of monitoring, extraction, or reinjection wells to confirm that groundwater flow conditions are similar to those shown in the 1995 RI data. Depth-to-water measurements will be collected from both the shallow and deep monitoring wells and installed in the sand unit during the RI investigation. Monitoring well locations installed during the RI are depicted in Figure 2.2. A summary of monitoring well construction information obtained from the 1995 Remedial Investigation Report is provided in Appendix B.

The water level in each of the monitoring, extraction, and reinjection wells will be measured using an electronic water level meter on a daily basis during the Pilot Project. Water level measurements will be recorded in the field logbook to the nearest 0.01 foot. Measuring devices will be decontaminated after each use as specified in the cleaning protocols presented in Section 3.2.2. In addition, a data logger/pressure transducer will be used to monitor water levels in selected wells during the Pilot Project (see Section 5.4.5).

5.5.3 FLOW MEASUREMENTS

The extraction and reinjection wells will be pumped with peristaltic pumps using dedicated long-life tubing which discharge through in-line flow meters. The accuracy of the in-line flow meters will be checked using bucket and stopwatch measurements. These confirmatory measurements will be conducted on a daily basis and the results will be recorded in the field book.

5.6 SURVEYING

CPT sounding, monitoring, extraction and reinjection well locations installed during the Pilot Project will be surveyed for horizontal and vertical control. An Illinois-registered land surveyor will perform the surveying activities. Locations will be surveyed to the nearest 0.5 foot for horizontal control and to the nearest 0.01 foot for vertical control. Vertical coordinates will be referenced to U.S. Geological Survey Average Mean Sea Level datum.

6.0 TREATABILITY STUDY SAMPLING

Treatability groundwater samples will be collected to facilitate bench-scale treatability testing. The following procedure will be followed to collect representative water samples for the treatability study:

i) 75 gallons of water will be collected from the first bulk storage tank when the tank is initially filled;

ii) the sample will be collected from the middle of the tank to minimize potential aeration of the sample;

iii) following collection, groundwater will be shipped immediately in headspace free containers to the laboratory.

Details regarding the treatability study protocols are provided in the Treatability Protocols Work Plan prepared for the Pilot Project.

7.0 ANALYTICAL PLAN

7.1 OVERVIEW

Water samples collected during the Pilot Project will be analyzed for TCL VOCs, TCL semivolatile organic compounds (SVOCs), ammonia, bromide, nitrate, total cyanide, thiocyanate, alkalinity, total arsenic, total phenol, and total suspended solids by En Chem Inc. of Madison, Wisconsin. Table 4.1 summarizes the sampling and analytical program during the Pilot Project. Table 7.1 summarizes the analytical methods for the Pilot Project.

7.2 SAMPLE HANDLING AND DOCUMENTATION PROTOCOLS

7.2.1 SAMPLE LABELING

Each sample will be labeled with a unique sample number that will facilitate tracking and cross-referencing of sample information. The sample numbering system to be used is described as follows:

Example: GW-15670-MMDDYY-XX-001

where:

GW	-	designates types of sample (GW-groundwater, S-soil, SD-sediment, SW-surface water)
15670	-	CRA's designated project number
MMDDYY	-	designates date of collection presented as month/day/year
XX	-	designates sampler's initials
001	-	designates sequential number starting with 001 at the start of the project

Field blank and field duplicate samples also will be numbered with a unique sample number, consistent with the numbering system described above, to prevent laboratory bias of field QC samples.

7.2.2 SAMPLE CONTAINERS AND HANDLING

Required sample containers, sample preservation methods, maximum holding times, and filling instructions are provided in the QAPP and on Table 7.2. All samples will be placed in appropriate sample containers, labeled, and properly sealed. The sample containers will be identified by sample labels. Sample labels will include sample number, date and time of collection, and analyses to be performed. Samples will be cushioned within the shipping coolers by the use of bubble pack. Samples will be kept cool by the use of plastic bags of ice, as required.

Samples will be shipped by commercial courier or hand delivered on a regular basis to the project laboratory. The exception to this will be samples that are collected on a Saturday, Sunday or holiday. For samples collected on a Sunday or holiday, additional ice will be placed in the coolers, as required, and the coolers will be sealed and kept under surveillance by a CRA representative. Immediately prior to shipment, on the next business day, the CRA representative will check the samples to ensure that the samples have been stored appropriately and have not been tampered with.

Two seals comprised of the engineer's chain-of-custody tape will be placed over the lid on the front and back of each shipping cooler prior to shipment to secure the lid and provide evidence that the samples have not been tampered with en route to the laboratory. Clear tape will be placed over the seals to ensure that they are not accidentally broken during shipment. The on-Site CRA representative conducting the sampling will be responsible for packaging the samples and sealing and delivering the cooler to an overnight courier.

Upon receipt of the cooler at the laboratory, the cooler will be inspected by the designated sample custodian. The sample custodian will note the condition of the cooler and seal on the chain-of-custody form. The sample custodian will document the date and time of receipt of the cooler and sign the chain-of-custody forms.

The sample custodian then will check the contents of the cooler with those samples listed on the chain-of-custody form. If damage or discrepancies are noticed, they will be recorded in the remarks column of the chain-of-custody form, dated and signed. They will be reported to the laboratory supervisor who will inform the laboratory manager and QA officer.

Sample disposal will be the responsibility of the laboratory. Upon disposal, the laboratory shall sign the next open "Relinquished by" box, and the word "Disposed" shall be written in the "Received by" box.

7.2.3 CHAIN-OF-CUSTODY FORMS

Chain-of-custody records will be used to track all samples from time of sampling to the arrival of samples at the laboratory. Each shipping container being sent to the laboratory will contain a chain-of-custody form. The chain-of-custody form consists of four copies, which are distributed to the sampler, to the shipper, to the contract laboratory, and to the office file of the engineer. The sampler and shipper will maintain their copies while the other two copies are enclosed in a waterproof enclosure within the sample container. The laboratory, upon receiving the samples, will complete the remaining copies. The laboratory will maintain one copy for its records. The executed original will be returned to the engineer with the data deliverables package.

7.3 QUALITY CONTROL

In accordance with the approved Work Plan, QC samples will not be collected during operation of the E/R and E Units. QC samples will only be collected during the pre-test and post-test monitoring described in Sections 4.4 and 5.4.6, respectively. The level of QC effort is discussed in the QAPP.

Data will also be obtained from field instruments and these data will be used in the interpretation of the Pilot Project results.

The QAPP prepared for this project provides specific details regarding protocols and checks associated with laboratory analyses and sampling procedures.

7.4 ANALYTICAL LABORATORY

Samples for chemical analysis will be delivered to the following laboratory:

En Chem Inc.
525 Science Drive
Madison, Wisconsin 53711
Telephone: 608-232-3312

8.0 PROJECT ORGANIZATION AND RESPONSIBILITY

CRA, as consultant to the WCP Group, has overall responsibility for all stages of the investigation. CRA will perform the sampling activities. All samples will be analyzed by En Chem Inc of Madison, Wisconsin.

All subcontracted firms will provide project management as appropriate to their responsibilities. CRA will maintain a file copy of all laboratory deliverables. All final project deliverables will be issued by CRA at the explicit direction of the WCP PRP Group. A summary of each of the key person's responsibilities is presented in the QAPP.

Primary responsibility for project quality rests with CRA's Project Manager. Independent quality assurance will be provided by the laboratory's Project Manager and QA Officer prior to release of all data to CRA.

During the sampling stage of the project, daily telephone contact between the field sampling personnel and the laboratory subcontractor will occur. The laboratory will provide status updates by means of preliminary data telefacsimiles. Should unexpected delays or other problems with the laboratory analyses occur, these would be communicated directly to CRA's Project Coordinator for resolution. Daily meetings with subcontractors will be held to update the progress of the project activities.

Key CRA contacts during the Pilot Project activities are:

Alan Van Norman - Project Manager	519-884-0510
Bruce Clegg - Project Coordinator	773-380-9933
Steve Day - QA Officer	773-380-9933
Steven Wanner – Senior Project Hydrogeologist and Field Quality Control Officer	773-380-9933
Jan Kochany – Senior Water Treatment Specialist	905-712-0510
Matthew Lazaric – Health and Safety Officer	773-380-9933
Walter Pochron – Field Coordinator	773-380-9933

9.0 HEALTH AND SAFETY PLAN

A Site-specific Health and Safety Plan (HASP) has been developed to address the Pilot Project related activities to be performed at the Site. All field activities will be conducted in accordance with the health and safety protocols outlined in the HASP. The HASP is presented as a separate document. The HASP may be modified in the future to incorporate additional activities proposed during supplemental activities.

10.0 PROJECT DATA MANAGEMENT

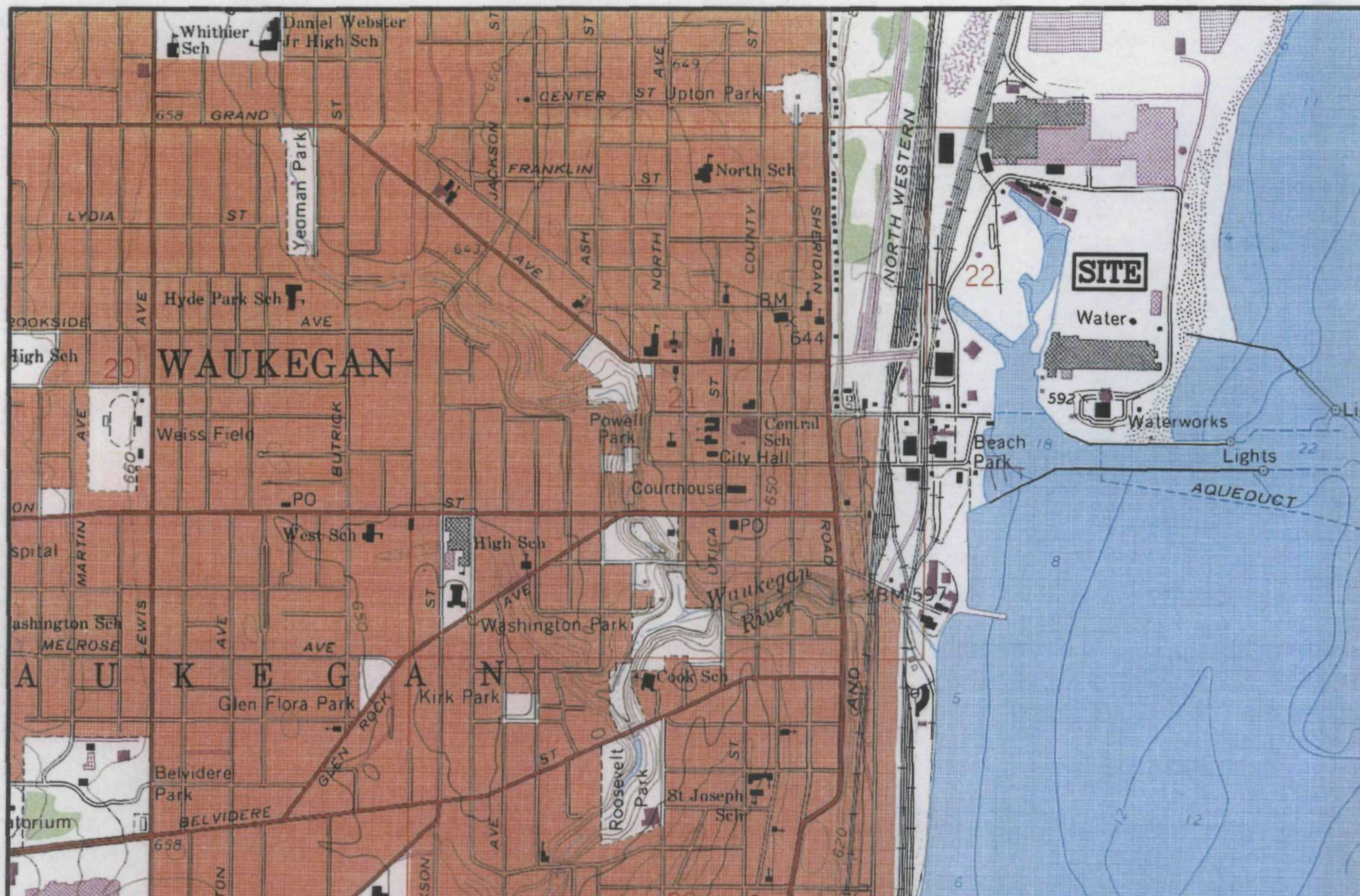
All field activities will be recorded daily in the field logbooks. Upon completion of the fieldwork or during periods when fieldwork is not scheduled, the field logbooks will be maintained in CRA's Chicago office. All data originals, including field forms, chain-of-custody forms, and laboratory data deliverables will be maintained in CRA's Chicago office.

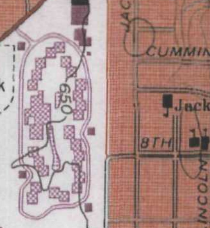
Computer-based data tables will be verified with original laboratory certificates of analyses and with the original field logbook or field-generated forms. Both hard paper copies and computer-based versions of summary tables will be saved in the files. Land survey data will be maintained in the project file as hard copy, and the electronic survey data will be stored with the project's AUTOCAD files.

11.0 SCHEDULE

The anticipated schedule for the Pilot Project is provided on Figure 11.1.

FIGURES





BASE SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE; WAUKEGAN, ILLINOIS 1960

figure 2.1

SITE LOCATION
WAUKEGAN COKE PLANT
Waukegan, Illinois

CRA

15670-00(002)GN-CO001 JUL 03/2000

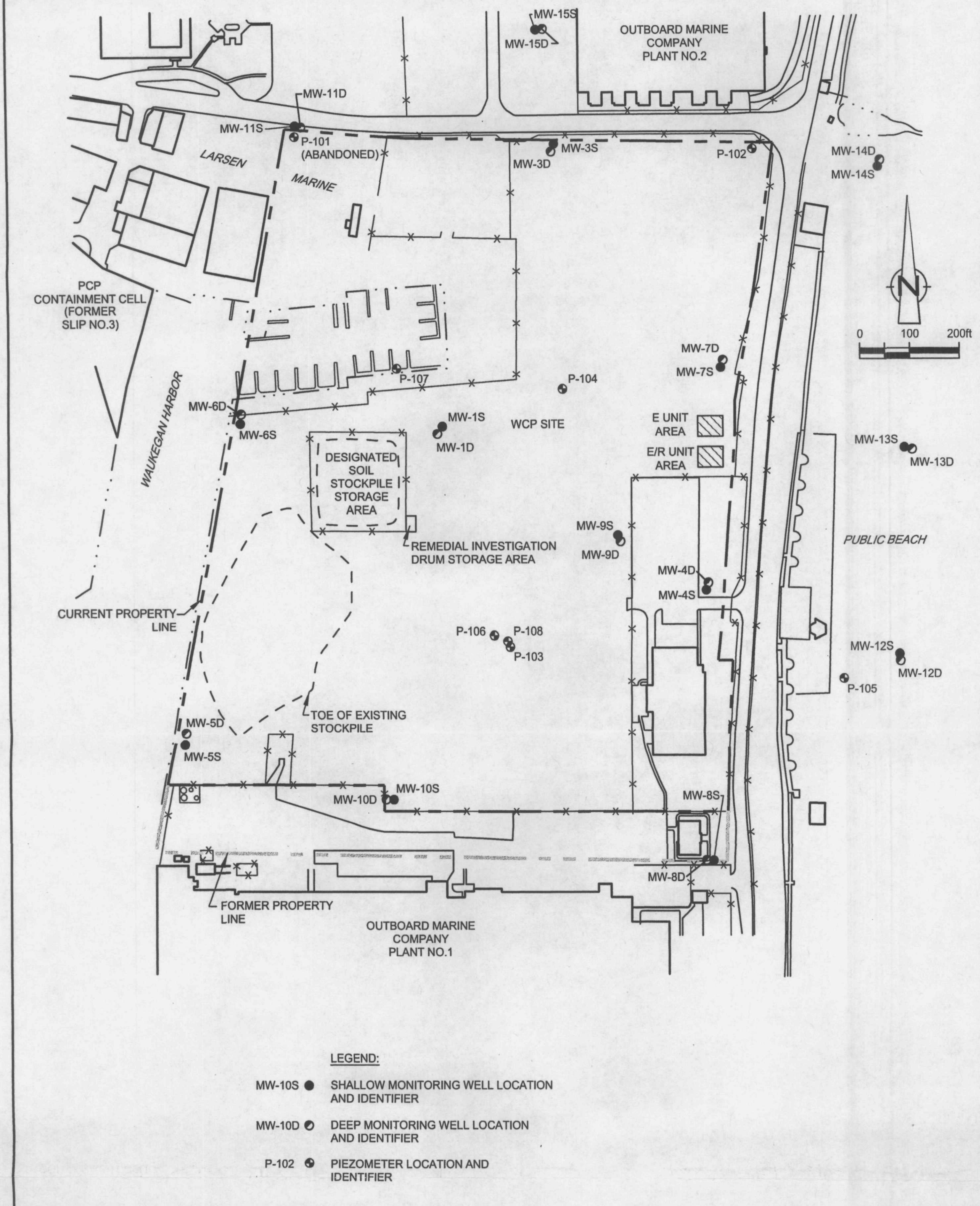


figure 2.2
SITE PLAN WITH
MONITORING WELL AND PIEZOMETER LOCATIONS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
Waukegan, Illinois

CRA

15670-00(002)GN-CO010 JUN 28/2000

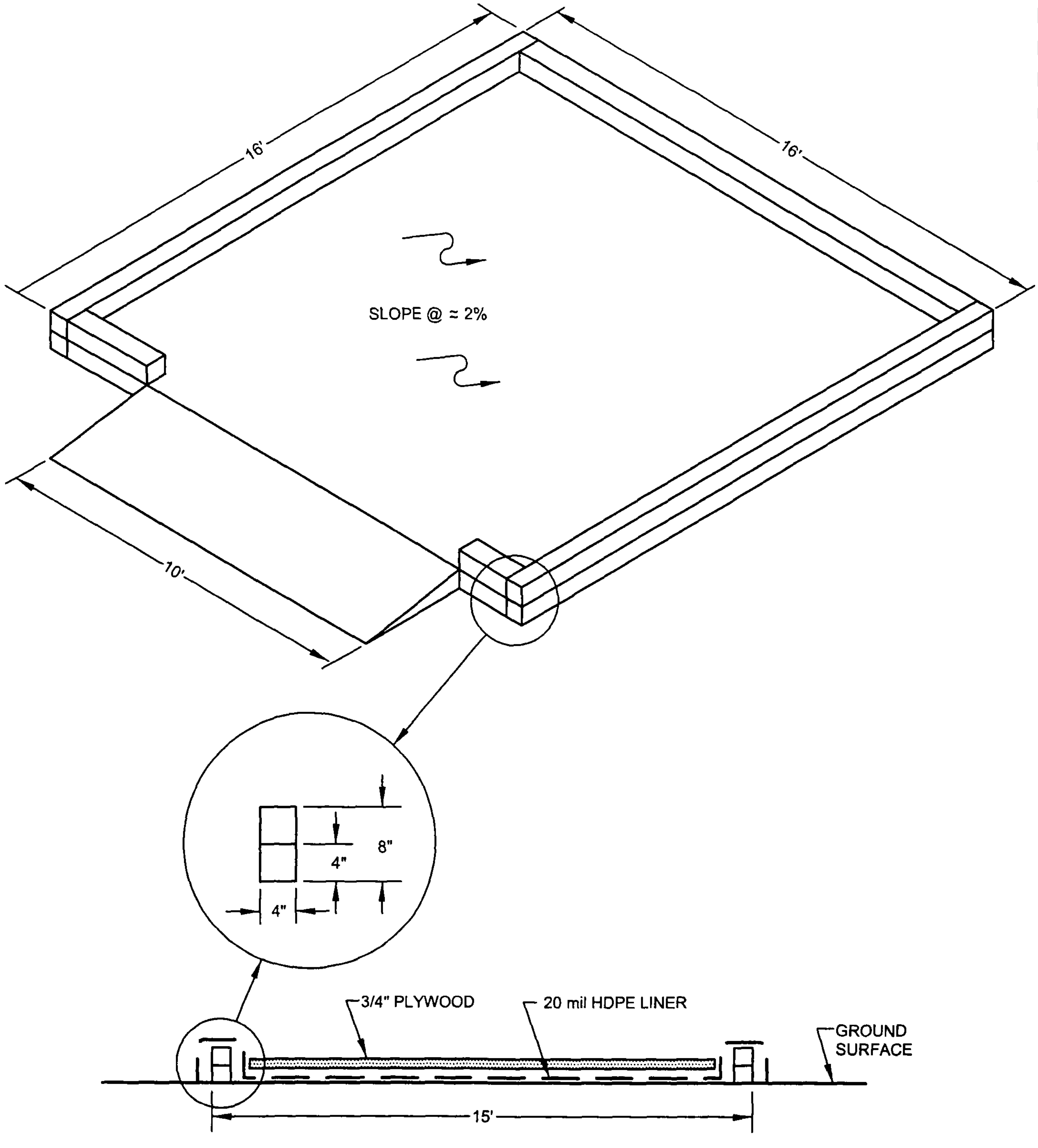
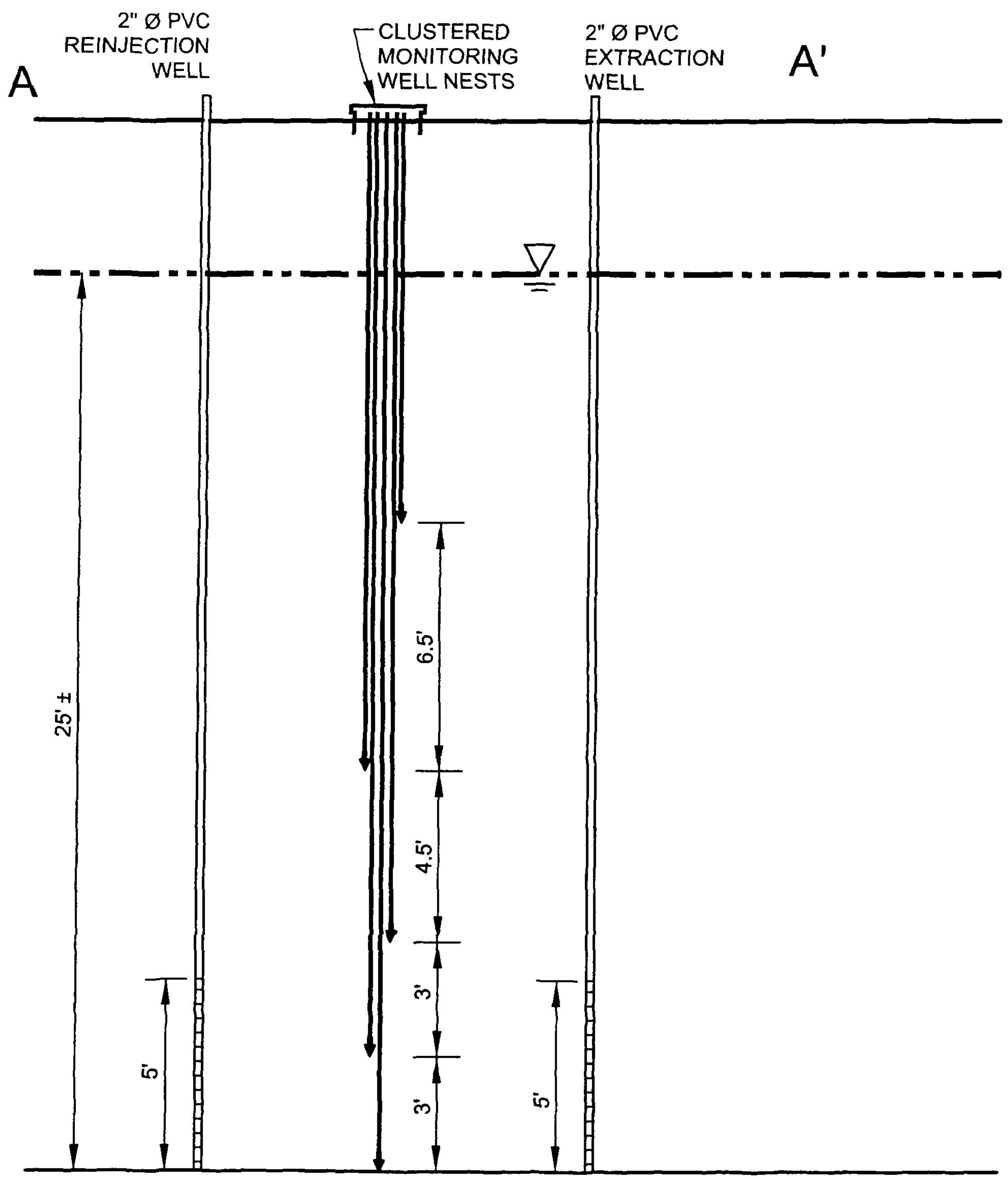


figure 3.1

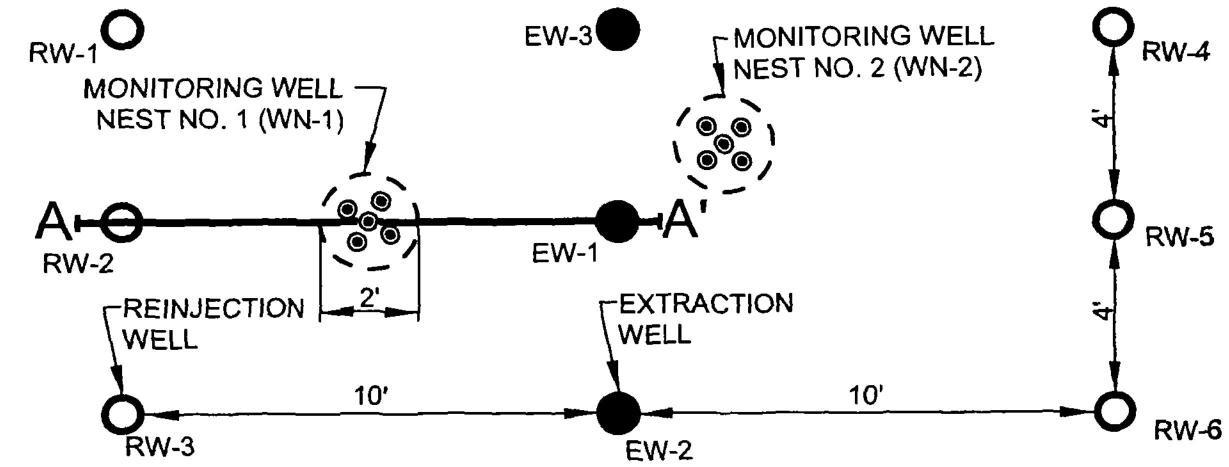
TYPICAL DECONTAMINATION AREA
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
Waukegan, Illinois

CRA

15670-00(002)GN-CO008 JUN 28/2000



CROSS-SECTIONAL VIEW



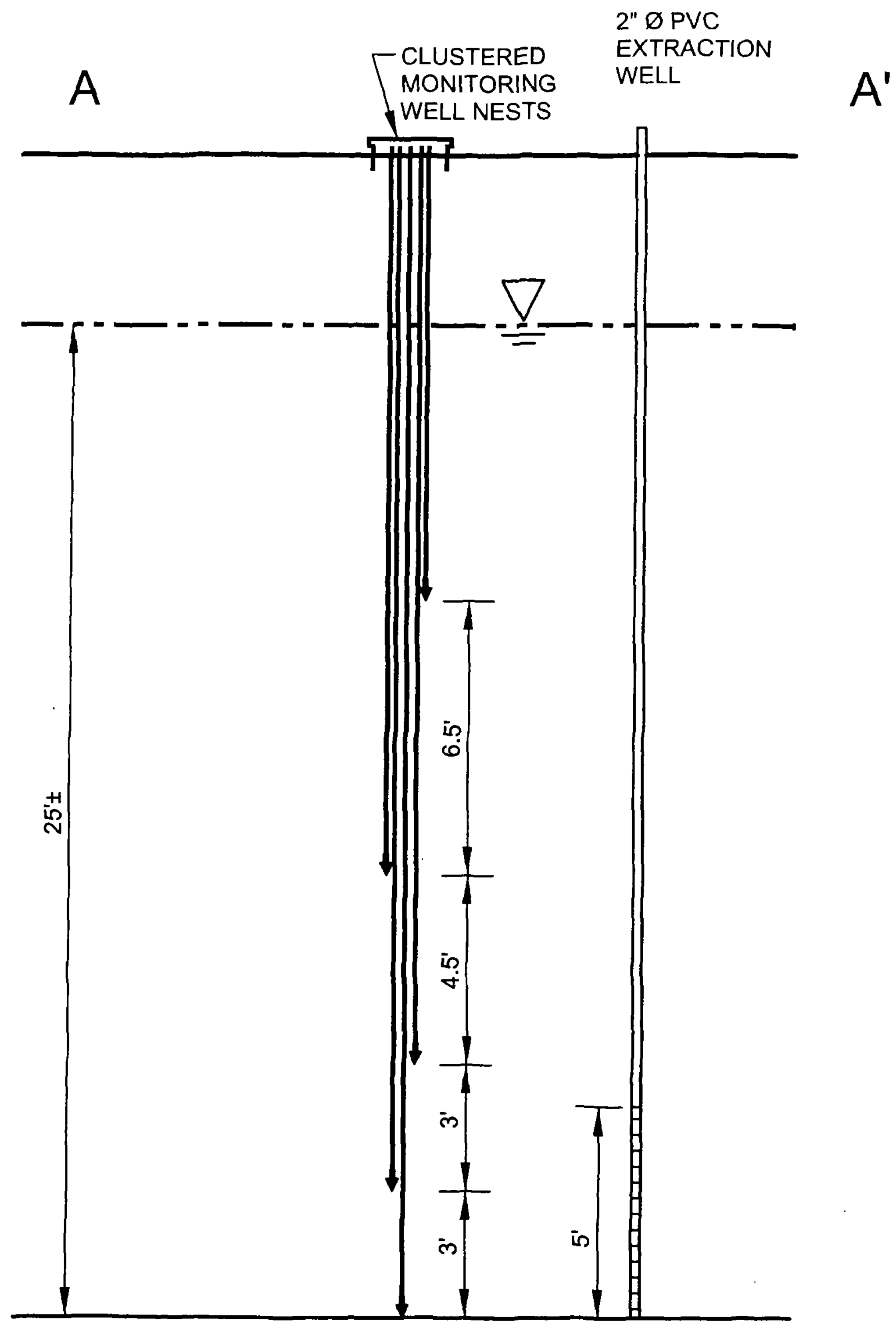
PLAN VIEW

figure 4.1

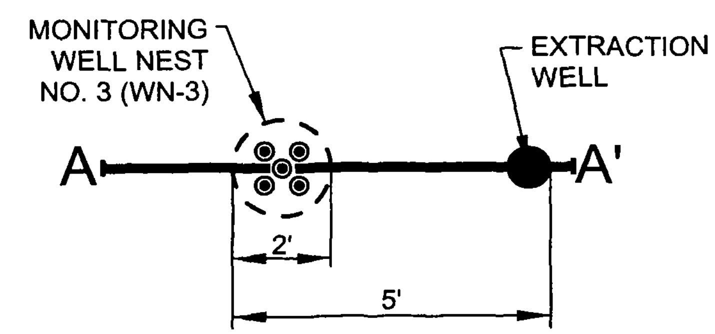
E/R UNIT SYSTEM CONFIGURATION
WAUKEGAN MANUFACTURED GAD AND COKE PLANT
Waukegan, Illinois

CRA

15670-00(002)GN-CO003 JUN 28/2000



CROSS-SECTIONAL VIEW



PLAN VIEW

figure 4.2

E UNIT SYSTEM CONFIGURATION
WAUKEGAN MANUFACUTERD GAS AND COKE PLANT
Waukegan, Illinois

CRA

15670-00(002)GN-CO004 JUN 16/2000

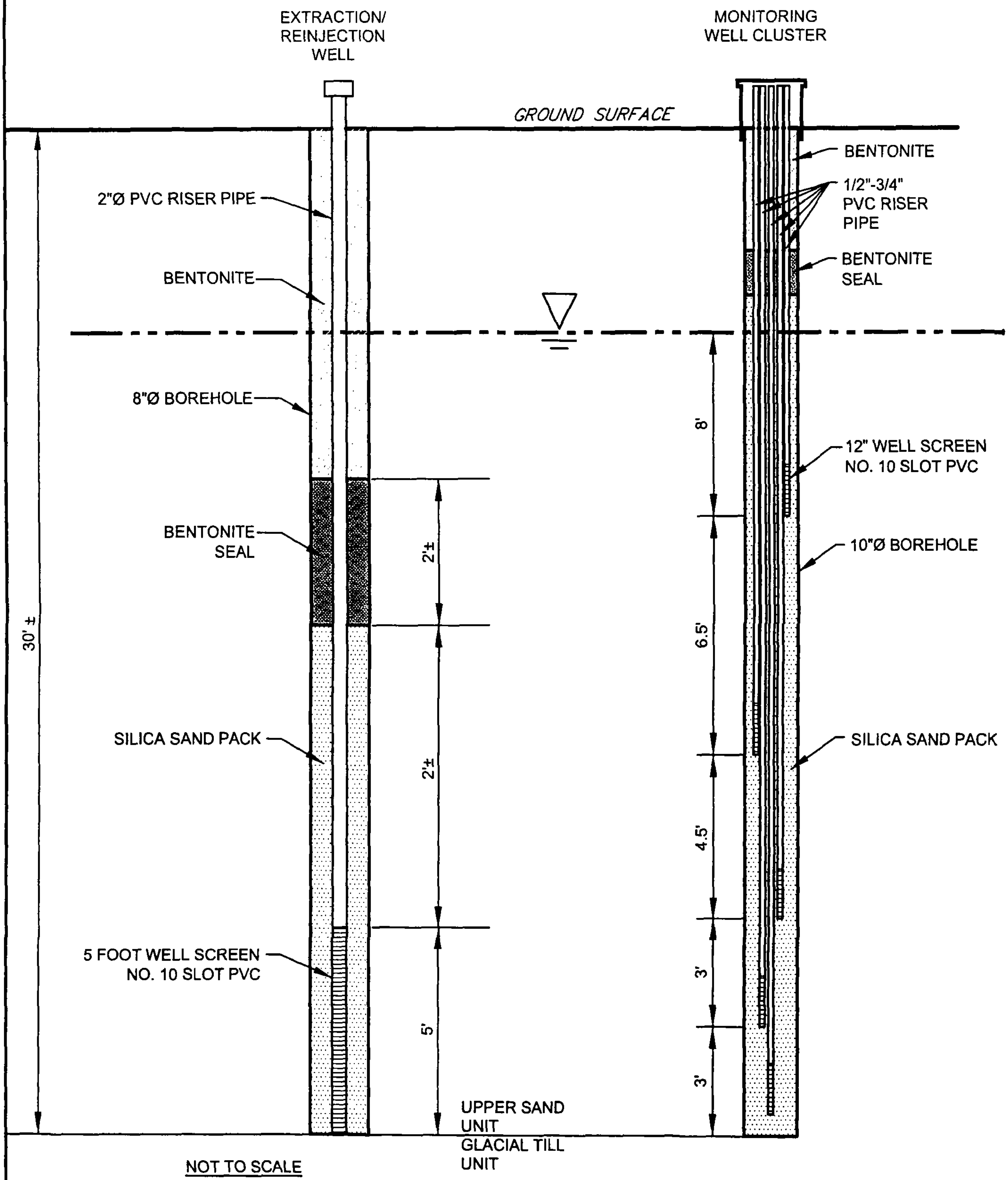


figure 4.3

EXTRACTION/REINJECTION
AND MONITORING WELL CONSTRUCTION DETAILS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
Waukegan, Illinois

CRA

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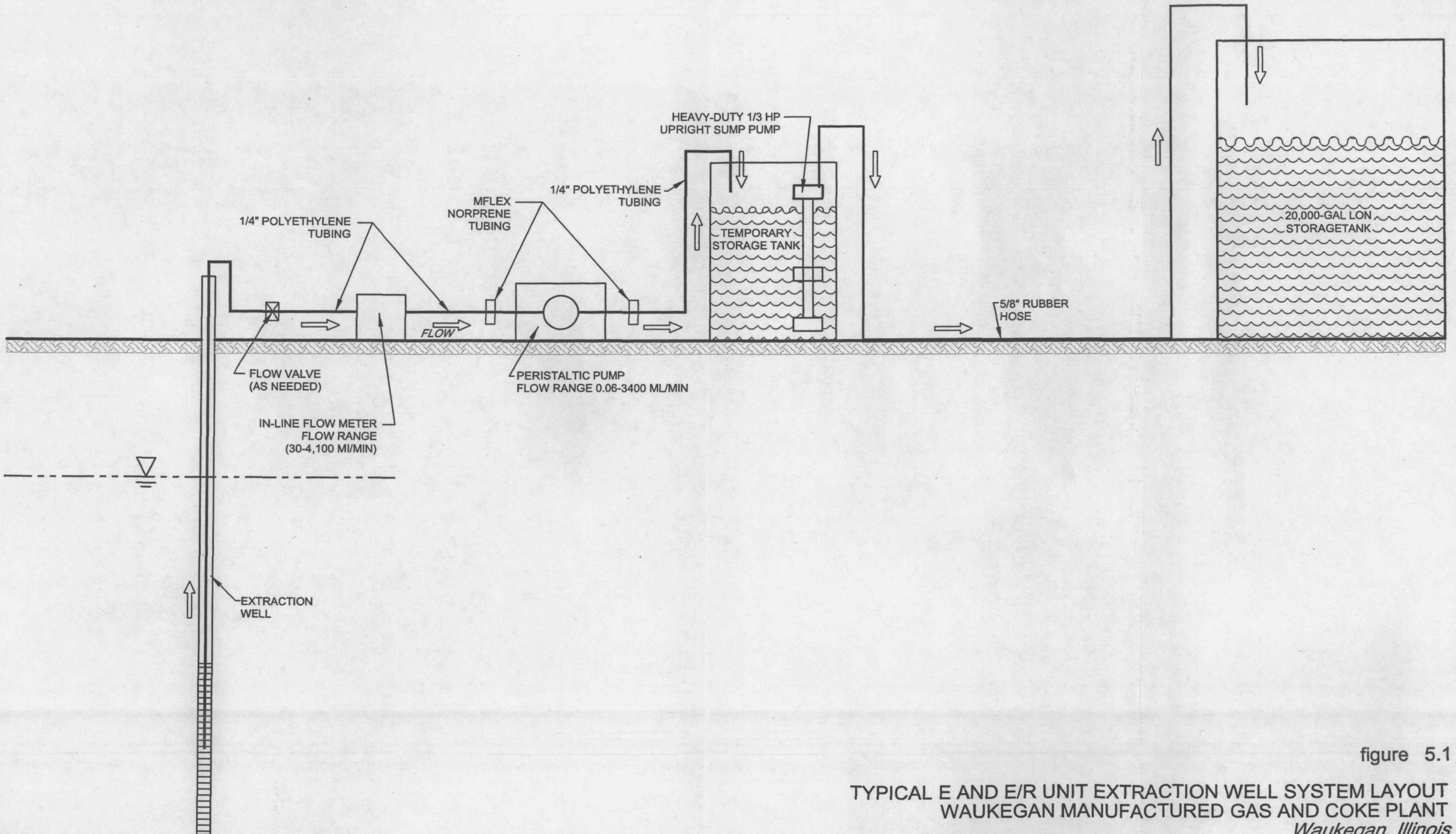

figure 5.1

TYPICAL E AND E/R UNIT EXTRACTION WELL SYSTEM LAYOUT
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
Waukegan, Illinois

CRA

15670-00(002)GN-CO006 JUN 08/2000

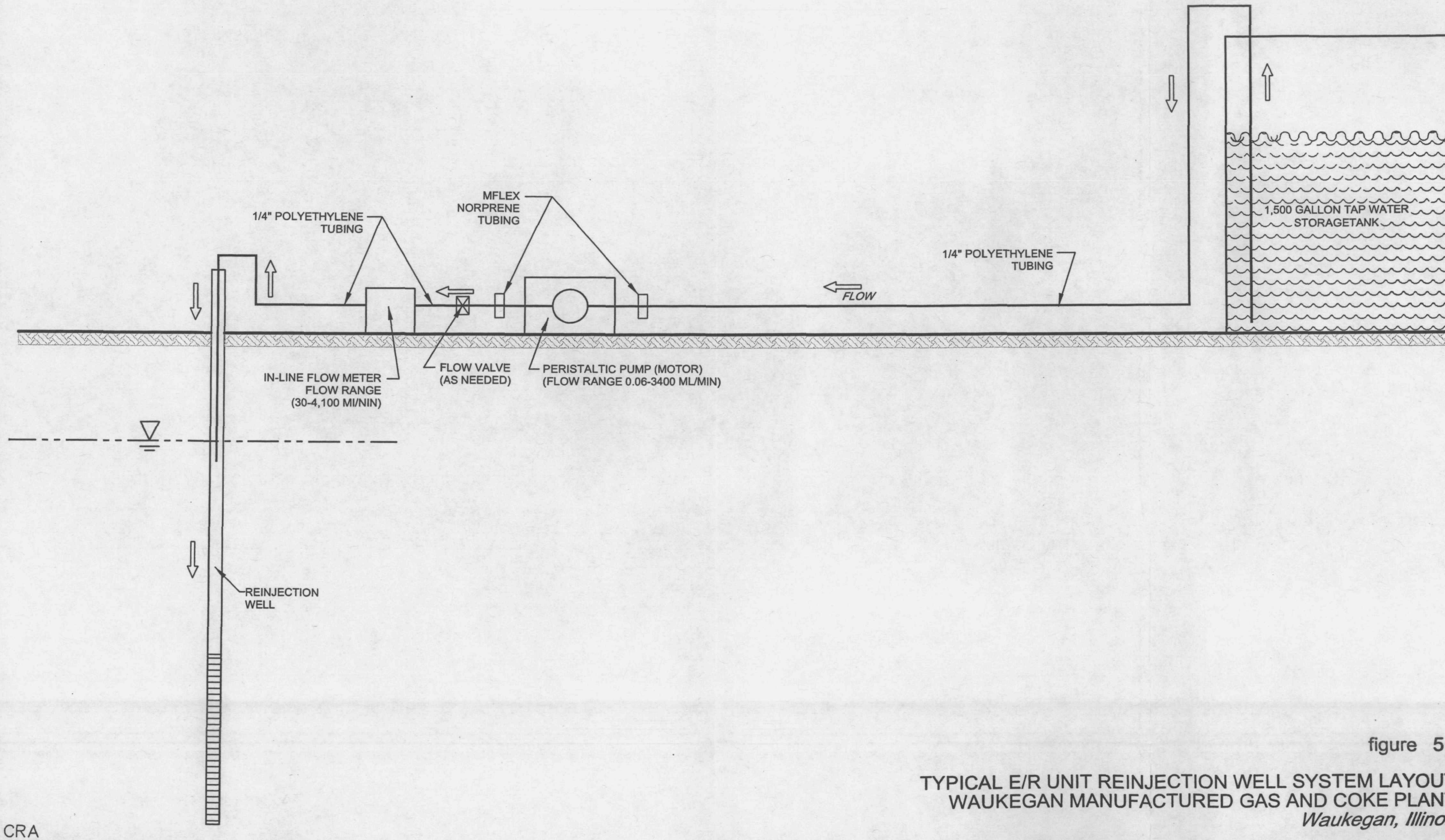

figure 5.2

TYPICAL E/R UNIT REINJECTION WELL SYSTEM LAYOUT
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
Waukegan, Illinois

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15670-00(002)GN-CO007 JUN 09/2000

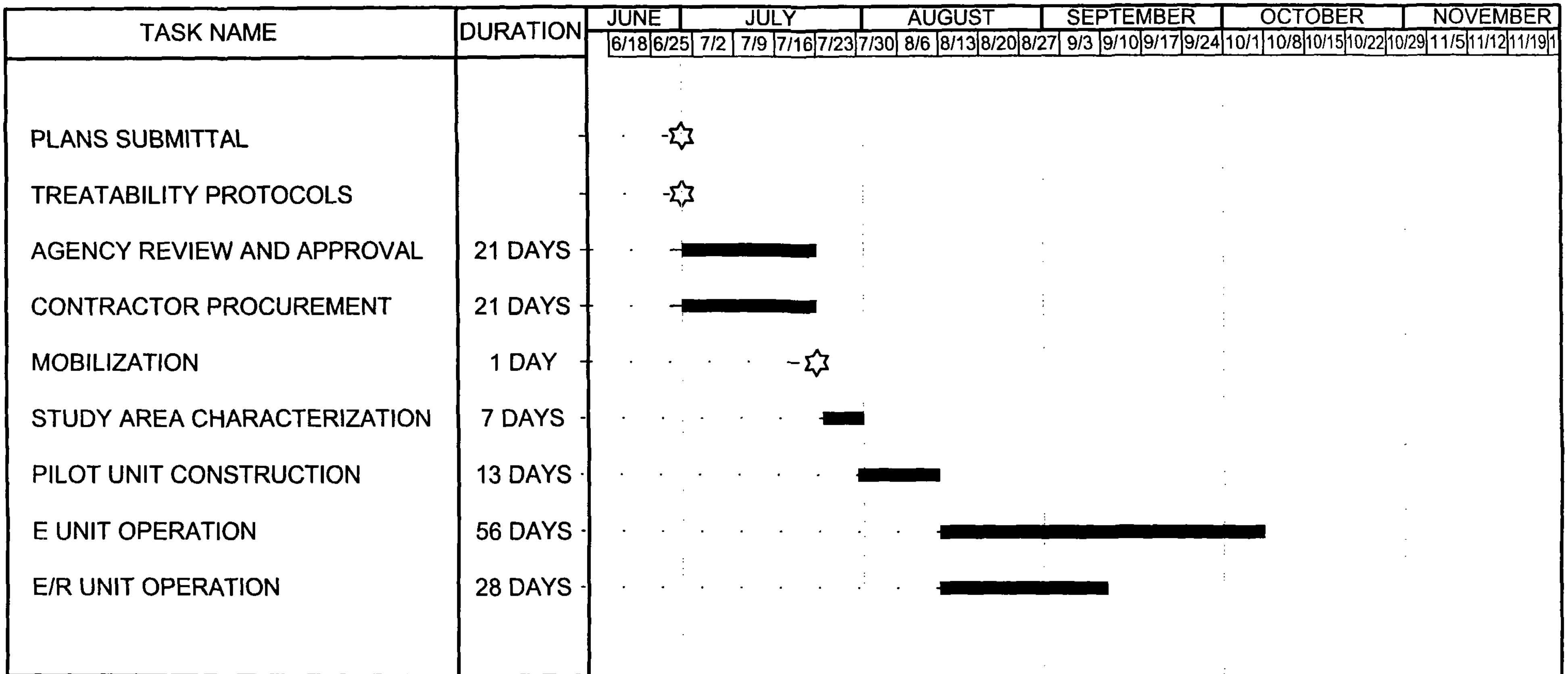

figure 11.1

ANTICIPATED PILOT PROJECT SCHEDULE
WAUKEGAN MANUFACTURED GAS & COKE PLANT
Waukegan, Illinois

CRA

15670-00(002)GN-CO009 JUN 28/2000

TABLES

TABLE 4.1

PILOT STUDY SAMPLING SUMMARY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Pilot Cell	Purpose	Week Number	Sampling Frequency	Locations Sampled	Number of Events	Number of Locations Sampled	Sample Points/ Location	Samples Per Event	Total Samples	Analyses: Total Phenolics	As[1]	Ammonia	Bromide	TCL VOC[2]	TCL SVOCs[3]	Nitrate	COD[4]	Cyanide	Thiocyanate	Alkalinity	TSS[5]
Extraction/Reinjection Unit	Contaminant Mass Removal Determination	Week 1	Once (Prior to Startup)	WN-1, WN-2	1	2	5	10	10	10	10	10	--	10	10	--	--	10	10	--	--
		Week No. 1	Daily	WN-1	7	1	5	5	35	35	35	35	--	--	--	--	--	--	--	--	--
		Week Nos. 2 through 4	3 Events/ Week	WN-1	9	1	5	5	45	45	45	45	--	--	--	--	--	--	--	--	--
		Week Nos. 1 through 4	3 Events/ Week	WN-2	12	1	5	5	60	60	60	60	--	--	--	--	--	--	--	--	--
		Week Nos. 1 through 4	Weekly	WN-1, WN-2	4	2	5	10	40	--	--	--	--	40	40	--	--	40	40	--	--
		One Week and Four Weeks Following Unit Shutdown	Twice	WN-1, WN-2	2	2	5	10	20	20	20	20	--	20	20	--	--	20	20	--	--
				Subtotal - Contaminant Mass Removal Determination E/R Unit					210	170	170	170	--	70	70	--	--	70	70	--	--
	Tracer Test	Week 1	Once (Prior to Startup)	WN-1, WN-2, EW-1, EW-2 EW-3, RW-1, RW-2, RW-3	1	11	11	19	19	--	--	--	19	--	--	--	--	--	--	--	--
		Week No. 1	Once (30 minutes following tracer injection)	RW-2	1	1	1	1	1	--	--	--	1	--	--	--	--	--	--	--	--
		Week No. 1	Daily	WN-1, EW-1 EW-2, EW-3, RW-2	7	5	9	9	63	--	--	--	63	--	--	--	--	--	--	--	--
		Week Nos. 2 through 4	3 Events/ Week	WN-1, EW-1 EW-2, EW-3, RW-2	9	5	9	9	81	--	--	--	81	--	--	--	--	--	--	--	--
				Subtotal - Tracer Test E/R Unit					164	--	--	--	164	--	--	--	--	--	--	--	--
	Extracted Water	Weeks 1 through 4	3 Events/ Week	EW-1, EW-2, EW-3	12	3	1	3	36	36	36	36	--	36	36	36	36	36	36	36	36
				Subtotal - Extracted Water E/R Unit					36	36	36	36	--	36	36	36	36	36	36	36	36
Extraction Unit	Contaminant Mass Removal Determination	Weeks 1, 3, 5, 7[6]	3 Events/ Week	WN-3	12	1	5	5	60	60	60	60	--	--	--	--	--	--	--	--	--
		Weeks 1, 3, 5, 7	Once/Week	WN-3	4	1	5	5	20	--	--	--	--	20	20	--	--	20	20	--	--
		Week No. 1	Once (Prior to Startup)	WN-3	1	1	5	5	5	5	5	5	--	5	5	--	--	5	5	--	--
		One Week and Four Weeks Following Unit Shutdown	Twice	WN-3	2	1	5	5	10	10	10	--	--	10	10	--	--	10	10	--	--
				Subtotal - Contaminant Mass Removal Determination E Unit					95	75	75	--	--	35	35	--	--	35	35	--	--
	Extracted Water	Weeks 1, 3, 5, 7	3 Events/ Week	EW-4	12	1	1	1	12	12	12	12	--	12	12	12	12	12	12	12	12
				Subtotal - Extracted Water E Unit					12	12	12	12		12	12	12	12	12	12	12	12
				TOTAL SAMPLES					517	293	293	218	164	153	153	48	48	153	153	48	48

As - Arsenic
TCL VOCs - Target Compound List - Volatile Organic Compounds
TCL SVOCs -Target Compound List - Semivolatile Organic Compounds
[1] COD - Chemical Oxygen Demand
[2] TSS - Total Suspended Solids
[3] Denotes weeks when E Unit is in operational mode (odd weeks) rather than shutdown mode (even weeks). No samples will be collected between Week 1 and Week 7 when the E Unit is in shutdown mode.
[4] WN = well nest
[5] EW = extraction well
[6] RW = reinjection well

TABLE 7.1

SUMMARY OF ANALYTICAL METHODS
WCP SITE PILOT PROJECT
WAUKEGAN, ILLINOIS

Parameter[1]	*Preparation Method Reference*[2]	*Analysis Method Reference*
Groundwater/Process Water		
VOCs	SW-846 5030B	SW-846 8260B
SVOCs	SW-846 3510C	SW-846 8270C
Arsenic	SW-846 3010A	SW-846 6010B
Alkalinity	SM 2320B	EPA 310.1
Ammonia	EPA 350.1	EPA 350.1
Bromide	EPA 300.0	EPA 300.0
Chemical Oxygen Demand	EPA 410.4	EPA 410.4
Chloride	EPA 300.0	EPA 300.0
Cyanide	EPA 335.4	EPA 335.4
Nitrate	EPA 300.0	EPA 300.0
Thiocyanate	SM 4500-CN-M	SM 4500-CN-M
Total Phenolics	EPA 420.2	EPA 420.2
Total Suspended Solids	EPA 160.2	EPA 160.2
Field Measurements - Groundwater Monitoring		
pH	NA[3]	EPA 150.1
Temperature	NA	EPA 170.1
Conductivity	NA	EPA 120.1
Dissolved Oxygen	NA	EPA 360.1
Oxidation-Reduction Potential	NA	SM 2580 B
Turbidity	NA	EPA 180.1

[1] VOCs - Volatile Organic Compounds
SVOCs - Semivolatile Organic Compounds
SOP - Standard Operating Procedure
[2] SW-846 - "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods", EPA SW-846, 3rd Edition with promulgated updates, November 1986.
EPA - "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, revised March
SM - "Standard Methods for the Examination of Water and Wastewater", APHA, 18th Edition, 19
[3] NA - Not Applicable

TABLE 7.2

CONTAINER, PRESERVATION, SHIPPING AND PACKAGING REQUIREMENTS
WCP SITE PILOT PROJECT
WAUKEGAN, ILLINOIS

Matrix	*Parameter* [1]	*Containers* [2]	*Preservatives* [3]	*Maximum Holding Time From Sample Collection* [4]	*Volume of Sample*	*Shipping*	*Packaging*
Groundwater/Process Water							
	VOCs	Three 40-mL glass septum vials	HCl to pH<2 iced	14 days for analysis	Fill completely	Lab or Overnight Courier	Bubble Wrap
	SVOCs	Two 1-liter amber glass bottles	iced	7 days for extraction, 40 days for analysis	Fill to neck of bottle	Lab or Overnight Courier	Bubble Wrap
	Arsenic	One 500-mL polyethylene bottle	HNO_3 to pH<2 iced	6 months for analysis	Fill to neck of bottle	Lab or Overnight Courier	Bubble Wrap
	Alkalinity, Bromide, Chloride, Nitrate, TSS	Two 1-L polyethylene bottles	iced	14 days for Alkalinity; 7 days for TSS 28 days for Chloride and Bromide 48 hours for Nitrate	Fill to neck of bottle	Lab or Overnight Courier	Bubble Wrap
	Ammonia, COD	One 1-L polyethylene bottle	H_2SO_4 to pH<2 iced	28 days for analysis	Fill to neck of bottle	Lab or Overnight Courier	Bubble Wrap
	Thiocyanate	One 500-mL polyethylene bottle	H_2SO_4 to pH<2 iced	14 days for analysis	Fill to neck of bottle	Lab or Overnight Courier	Bubble Wrap
	Cyanide	One 500-mL polyethylene bottle	NaOH to pH>12	14 days for analysis	Fill to neck of bottle	Lab or Overnight Courier	Bubble Wrap
	Total Phenolics	One 1-liter amber glass bottle	H_2SO_4 to pH<2 iced	28 days for analysis	Fill to neck of bottle	Lab or Overnight Courier	Bubble Wrap

[1] VOCs - Volatile Organic Compounds
SVOCs - Semivolatile Organic Compounds
TSS - Total Suspended Solids
COD - Chemical Oxygen Demand

[2] To the extent possible, parameters will be combined into as few sample containers as possible with respect to sample preservation requirements.

[3] Samples requiring refrigeration will be shipped with bagged, cubed ice and will be stored by the laboratory at 4°C ± 2°C following sample receipt and log-in.

[4] Sample holding time will be calculated from the time of sample collection to sample analysis.

APPENDIX A

CONE PENETROMETER STANDARD OPERATING PROCEDURES

PENETROMETER TEST PROCEDURES

The following procedures are used by STRATIGRAPHICS in performing penetrometer testing.

1. The sounding location is evaluated for surface obstructions or overhead utilities. The local traffic situation is also evaluated. The Client Representative is queried if he has obtained all subsurface utility clearances in area. Client's authorization to proceed with subsurface exploration at location is received.

2. The penetrometer rig is moved onto location. A laser alignment beam is used to position the rig on location if an ultra-high (less than 0.5 inch) degree of accuracy is required, such as during CPT through cored holes in pavement. For most work, visual alignment is used for positioning, typically placing the rig within 1 ft of the planned location. Crew notes down in field log sheets any unusual setup situations, including pavement or cored hole.

3. The zone immediately around the test point is checked for proper seating of grout seals for use in pressure grouting the hole. Surface leveling is performed if a seal might not be developed. Dry granular grout is used to develop a seal on a rough surface that cannot be leveled.

4. The penetrometer rig is leveled using the hydraulic leveling system. Rig lateral and longitudinal levels are checked using a bubble or electronic level placed on the rod clamp. Once rig is leveled, begin GPS data logging, if required. Check lightning detector antenna alignment, if it is being used.

5. The CPTU-EC penetrometer is visually observed for wear or damage. If a piezometric sounding is to be performed, the piezometer elements are de-aired using the vacuum saturation system. Piezometer filters are replaced before every sounding if clays were encountered in the previous sounding or if filter damage or clogging is observed. A maximum of three soundings can be performed with a single filter set if filter damage or clogging is not observed.

    a) The CPTU-EC piezometric filters are de-aired using the vacuum saturation system until few bubbles are observed flowing from the filters. Piezometric transducer output is checked versus vacuum gauge pressure. In general, use of the hi-vacuum electric pump results in -0.98 to -1.00 tsf of vacuum measured at the transducer. A vacuum of -0.92 to -0.96 tsf is typically measured when de-airing filters using the air operated vacuum pump.

    b) piezometric response is checked by developing a full vacuum in the saturation chamber, followed by quick release of vacuum to atmospheric pressure. Transducer response should reflect this change within about 2 seconds. Much slower response indicates poor saturation or a clogged filter. Continue saturation or change filters. Crew notes down on field log sheets whether piezometer saturation procedures were performed.

6. The soil electrical conductivity (EC) module is checked by applying a series of calibration resistors across the electrodes and monitoring EC channel output. High output (+15,000 uS/cm) in air indicates an electrode short to case. Low output or no output when the resistor is applied to electrodes indicates an open circuit. Crew notes on field log sheets which calibration resistor was used and what reading was obtained during the EC check.

7. The UVF module consists of a sapphire window in the side of the penetrometer, a UV light source, filters, and photonic sensors. The UV light source illuminates the soil next to the window. If the soil contains compounds, such as petroleum hydrocarbons, that fluoresce, the resulting light can be detected with photonic sensors. The intensity of the fluorescence can often be related to the concentration of contamination in situ.

   The UV light source is bandpass filtered at 254 nm to provide a light of very narrow wavelength for excitation of soil compounds next to the sapphire window. The photonic sensor is high pass filtered at 290 nm to sense resulting flourescence from soil compounds, next to the sapphire window, under the excitation of the 254 nm UV light source.

   Prior to performance of a CPT-EC-UVF sounding, the operator turns on the UV light source, and allows at least 5 minutes of warmup time, before performing subsurface exploration. Other calibration procedures may be performed during this warmup period.

   The photonic sensor operation is checked by exposing the sapphire window to ambient light within the penetrometer rig. A high light signal of about 4.500 Volts is obtained under ambient light conditions. A light blocking magnet is then used to cover the sapphire window, cutting off ambient light to the photonics sensor. A dark signal of about 0.200 to 0.500 Volts is obtained with the blocking magnet covering the window. The blocking magnet is then turned over and applied to the window. A flourescent target, mounted on the back of the magnet, is thus exposed to the UV light, and results in a high target sensor output of about 3.000 to 4.000 Volts. If the UV light source is not operational, only a dark signal level will be obtained during this step.

   Finally, the CPT-EC-UVF penetrometer is lowered into the rig centerwell as part of beginning subsurface exploration. While the penetrometer and UVF window are inside the centerwell, and the centering guides have been mounted around the rod string (see Step 9), the operator checks the zero output of the UVF sensor. Since the steel centerwell is opaque to light, and sealed at the bottom with rubber seals, and blocked at the top with steel centering guides, the centerwell provides a repeatible, very low light level environment for zeroing the UVF sensor. If sensor output is greater than +/- 0.100 Volts, the operator should reset zero levels for the sensor. Once the UVF window is below the ground surface, sensor output may be below zero levels (-0.100 to -0.300 Volts) as light levels in the soil may be less than in the centerwell. However, the centerwell is used for zeroing, as it provides a repeatible very low level light condition.

8. The penetrometer load cells are checked by manually loading the penetrometer and noting a positive response of about 10 to 50 lbs on both cone tip and friction (total) load cell outputs. The friction loadcell should be checked next by manually pushing on it while avoiding the cone tip. Total loadcell output should change, with little change in cone tip loadcell output.

   The shunt calibration is used at this point to verify proper transducer response. When pushing the shunt cal button, a full scale response of about 23,000 lbs should register on both load cell outputs for the S1510 series penetrometers. A full scale output of about 26,000 lbs should register on both load cell outputs for the S1500 series penetrometers. A full scale output on channels Cone1 and Total1 of 32,768 lbs is registered for S2000 series penetrometers, with about 59,000 and 75,000 lbs registering on Cone2 and Total2, repectively.

   Inconsistent and floating output can be indicative of damage to transducers, especially caused by water flooding of the penetrometer. This gets worse with time. Penetrometers must be changed immediately in this situation.

Changes in loadcell output when the penetrometer is grounded to the rig indicate ground loop problems, possibly caused by moisture in the penetrometer. If small changes occur, the penetrometer might be temporarily kept in operation, with close attention paid to zero load consistency. Output of full scale readings, typically +/- 22,000 or +/- 26,000 lbs indicate an open circuit. Check connectors for fit and cabling for cuts in this situation.

9. Check depth encoder operation by rotating encoder wheels. Make sure that encoder temperature is greater than 32 degree F. The encoder may not work consistently if it is colder than this. Check encoder wheels to make sure they are free of all oils, and are relatively clean and dry. If wheels are oily, clean wheels with alcohol wipes, making sure wheels are absolutely dry after cleaning.

   The penetrometer is clamped into the push system at this time and the first two sections of sounding rod are added. The penetrometer is then lowered into the centerwell. Centering guides are fitted around the sounding rods when the enlarged portion of the penetrometer has passed the top of the centerwell. Centering rings are fitted to the rod string after the centering guides have been lowered below the top of the centerwell. (See section on UVF zeroing).

   Lowering of the penetrometer to the grout seal is monitored using the closed circuit camera and monitor (CCTV). The penetrometer is lowered until the conical tip is level with the grout seal and the depth encoder is reset. The rod string stickup, relative to the push table, is measured at this point.

   The penetrometer is raised about 4 inches at this point, to ensure that no loads are being applied to the loadcells during autozero procedures. Crew notes in field log sheets all transducer start zero readings, including penetrometer temperature, if the penetrometer includes a thermal sensor. Data logging software is initialized by entering sounding file name.

10. Data logging software is initiated by keystroke command. The software autozeros the cone and friction (total) loadcells. The operator counts 5 seconds, pushes the shunt cal button for another 5 seconds, and begins the sounding. This procedure permanently records initial zeros and shunt calibration values onto the sounding disk file. Operator verifies that loadcell values of about 33,000 (S2000 series), 23,000 (S1510 series) or 26,000 (S1500 series) lbs are displayed during the shunt cal procedure.

11. Begin pushing the penetrometer into the ground. Observe, using the CCTV, the verticality of the initial penetrometer push. Do not continue sounding if significant (+1/2 inch) deviation from vertical occurs. Begin pumping grout, if required, after penetrometer is about 3 to 5 ft in ground. Do not allow grout to get on piezometric elements as the grout will clog filters.

12. Continue adding rods and pushing penetrometer into the ground while monitoring hydraulic pressures and transducer on-screen display. Observe loadcell output during rodbreaks (while rod clamp is released to add next rod). Friction output can go negative, but cone end bearing should never go negative, other than during rod string pullback. Note down depths at which negative cone tip output occurs. Pump in about 2 pump strokes of grout for every 5 to 8 rods added to string.

    Monitor that depth encoder is performing properly by noting changes in depth. Depth change at 1 Hz logging frequency should be about 0.08 ft per scan. Depth change per sounding rod added is 3.28 feet. If much less depth change is occurring, stop and inspect encoder wheels. Oil on wheels can cause slippage. Clean wheels with alcohol and dry extremely thoroughly. Use hot air drier if possible. If slippage has occurred, note down all rod break depths for rest of sounding, or until all signs of slippage have stopped. Repeat wheel cleaning if slippage re-occurs.

13. At target depth or refusal, count number of rods left in rack and measure stickup relative to push table and record values. Compute actual depth of sounding and note on field log sheet. End data logging and begin processing log.

14. If rod string decontamination is to be performed, make sure steam cleaner feed pump is on and steam cleaner is set to auto mode. Begin pulling rods. Monitor waste water container. Grout hole using about 2 pump strokes every 3 rods pulled.

15. Pull penetrometer to about 3 inches above grout seal. Note down all transducer end zeros and penetrometer temperature. Lower penetrometer into grout seal to plug it. Pump in additional grout until hole is full. Note total amount of grout that was pumped into the hole. About 1/2 to 3/4 of a gallon are needed to grout 10 ft of hole.

16. Leave steam cleaner on as penetrometer is pulled through rod washer if piezometer saturation is to be performed, or if penetrometer is to be handled. Turn off steam cleaner and rinse penetrometer with cold water from pressure hose if a sounding not requiring piezometer saturation is to be performed immediately.

17. Finish processing sounding log. Shut down GPS logging, if performed. Strap rod rack. Lower truck back onto ground and pull away from hole. Check grout level. Add dry granular grout to make up for liquid grout penetration into permeable strata. Note down how much grout was added. Patch pavement, if required. Clean area, if required.

18. Repeat steps 1 to 17 for next sounding.

PENETROMETER SAMPLING

1. Set up rig as per Steps 1 to 3 in PENETROMETER TEST SECTION.

2. Decon and assemble sampler (soil, gas or groundwater) as per sampler Instruction Sheets. For most projects, sampler decon procedures consist of:

    a) steam clean used sampler to remove all dirt and fluids.
    b) dis-assemble sampler and discard contaminated filters, or other absorbent materials.
    c) wash sampler parts using potable water and Alconox solution. Use bottle brushes to clean inside of barrels and slides.
    d) rinse sampler parts in potable water.
    e) steam clean sampler parts and rinse with DI water.
    f) lay out parts to drain and air dry on decon table.
    g) assemble sampler as per Instruction Sheets.

3. Clamp sampler into push system and lower to grout seal (see Penetrometer Test Steps 8 and 9).

4. Push sampler to top of required sampling depth if sampling soils; push sampler to bottom of interval if sampling soil gas or groundwater (see Penetrometer Test Steps 12 thru 14).

5. If sampling for soil, lower wireline piston unlocking tool. Latch tool to piston assembly. Pull wireline about 1 inch to release piston. Mark stick-up and push rod string 1.5 ft while holding wireline in fixed position. Wireline will release at end of stroke. Retrieve wireline. Retrieve sampler to obtain sample.

6. If sampling for soil gas, lower water level indicator to top of slide. Mark stickup and pull back rod string to open slide assembly. Use water level indicator to indicate slide opening. Retrieve water level indicator. Attach rubber stopper to rod string. Evacuate rod string using air vacuum pump - note down system vacuum. If a vacuum less (more negative) than about -12 inches Hg is noted, suspect that sampler has been opened below water table or in capillary fringe. If vacuum quickly approaches -28 inches Hg then suspect sampler slide has not opened or groundwater is being pulled into the rod string.

7. If sampling for groundwater, mark stickup and slip balloon over end of rod string. Pull back on rod string to open sampler slide. As slide opens, balloon will deflate, and then balloon will begin inflating as groundwater flows into sampler. Rate of sampler inflow is reflected in balloon inflation rate. Measure water levels if requested.

QUALITY ASSURANCE

The key to quality assurance is system design, operator experience and adherence to procedures. STRATIGRAPHICS penetrometers are simple, robust tools, including features to maximize depth capability while assuring high data quality. Data logging equipment features ultra high 16 bit A/D resolution. Andrew Strutynsky, system designer and operator, has years of experience in performing penetrometer testing.

Test data are monitored by the engineer as the CPTU-EC-UVF soundings are performed. Field results may be used immediately to guide concurrent drilling and sampling operations. Data are recorded on floppy and hard disk. Measured channels consist of: depth, time, cone end bearing resistance, friction sleeve resistance, piezometric pressure, total load on penetrometer, soil electrical conductivity and uv induced flourescence. Penetrometer temperature can also be recorded.

Prior to beginning a sounding, the operator manually records the zero load output of the penetrometer. At test initialization, the data logging software auto-zeros the cone tip and friction (total) loadcells. The operator then runs a shunt calibration procedure, which is recorded into the sounding log digital file. At the end of the sounding, zero readings are again manually recorded by the operator.

Zero-Error The chief quality concern in CPT load measurements is zero offset error. Zero accuracy is affected by two components - mechanical offsets and thermal offset.

Mechanical offsets are caused by dirt in seals of the penetrometer, seal compliance problems, and misalignment of components. To minimize mechanical offsets, experience and laboratory testing (Ref. 9) has shown that the stiffest (highest capacity) loadcells and in line loadcell design (subtraction type) give the most accurate results. This is because stiff loadcells minimize relative movement between components, thus minimizing ingress of dirt into the system and seal compliance problems.

The in-line design minimizes mis-alignment of components, and lessens the number of seals needed to keep soil and groundwater out of the penetrometer. STRATIGRAPHICS uses a high accuracy, high capacity in-line design for its penetrometers.

Thermal offsets are caused by frictional heating of the penetrometer as it is pushed through dense, sandy soils. Another source of thermal offset is steam cleaning of the penetrometer. A solution to thermal offset problems is to add thermal compensation elements to the penetrometer loadcell circuits, as is done by STRATIGRAPHICS. Zero readings must also be obtained prior to the penetrometer being steam cleaned.

To evaluate zero errors during penetration testing, STRATIGRAPHICS relies on two techniques:

1) zero readings before and after testing are recorded for every sounding. If significant zero drift has occurred during a sounding, the penetrometer is disassembled and cleaned, seals removed, checked, and replaced, if necessary; and

2) data recording during the sounding is done on a time basis rather than on depth basis. Thus, data are continually recorded, even while the penetrometer is not being advanced and penetrometer loadcells are unloaded during addition of sounding rods. Zero shifts can be detected by the magnitude of forces measured on the unloaded loadcells. The unload cycle data are removed from the final plot of penetration resistance versus depth through the use of software techniques.

In contrast, depth base recording, as is common in most of the penetrometer industry, does not allow for data acquisition during rod breaks. Data are only acquired while the cone is being advanced. This low cost approach to CPT does simplify data processing and field memory requirements. However, the simplification of data acquisition procedures results in loss of important field Q/A data.

Analog to Digital (A/D) Data Conversion To record and process CPT data it is necessary to convert the analog signal coming from the CPT instrument to a digital value compatible with the computerized data acquisition system. STRATIGRAPHICS utilizes an ultra high accuracy 16 bit A/D converter for this purpose.

A 16 bit analog to digital conversion provides +/- 32768 counts of digital resolution. Since the STRATIGRAPHICS penetrometers consist of two 30,000 lbs load cells, the digital resolution is better than 1 lb. By using software controllable signal conditioning gain, a digital resolution of 5 ounces (or 0.01 TSF) is achievable for work at very soft sites.

In contrast, review of equipment specifications of other CPT operators reveals use of 12 bit A/D conversion. This results in digital resolution of +/- 2048 counts. Thus, for a 30,000 lb load cell, the digital resolution is only 15 lbs, or more than an order of magnitude worse than the STRATIGRAPHICS system.

This lack of digital resolution is significant in weak soils, especially when using subtraction type instruments. Data is indicative of poor digital resolution has a characteristic step function appearance, rather than the smoothly varying actual soil response.

Depth reference Sounding depths are encoded using a bi-directional distance encoder coupled directly to the rod string. This avoids push system compliance errors. Depth encoders coupled to the thrust cylinders instead of the sounding rod string can provide erroneous information due to thrust frame and sounding rod compliance, especially during hard pushing. Depth encoders coupled to the rod string can give erroneous information if rods are allowed to become oily.

To monitor depth encoding accuracy, STRATIGRAPHICS keeps a manual record of rod string stickup prior to starting a test and at test completion. The number of rods used and rod string stickup allows computation of the exact depth of soil penetrated. These checks are used in depth Q/A procedures.

APPENDIX B

WELL AND PIEZOMETER CONSTRUCTION SUMMARY - 1995 RI REPORT

TABLE 4.2-1

WELL AND PIEZOMETER CONSTRUCTION SUMMARY

WELL	ELEVATION (FT MSL)				DEPTH (FT BGS)		SAND PACK LENGTH (FT)	SCREEN LENGTH (FT)	SLOT SIZE (IN)	WELL DIAMETER (IN)	RISER AND SCREEN MATERIAL
	GROUND[1]	RISER[1]	BOTTOM OF		BOTTOM OF						
			BOREHOLE	WELL	BOREHOLE	WELL					
MW-1S[7]	586.0	587.76	568.0	568.5	18.0	17.5	7.5	5.0	0.010	2	SS
MW-1D[7]	585.8	587.62	557.8	558.1	28.0	27.7	7.0	5.0	0.010	2	SS
MW-3S	585.2	588.24	572.2	573.2	13.0	12.0	12.0	10.5	0.010	2	SS
MW-3D	585.5	588.23	557.5	557.7	28.0	27.8	10.0	5.0	0.010	2	SS
MW-4S[2]	586.3	586.16	572.3	574.3	14.0	12.0	13.0	10.3	0.010	2	SS
MW-4D[3]	586.1	585.93	554.1	554.1	32.0	32.0	10.0	5.0	0.010	2	SS
MW-5S	585.4	587.89	570.4	572.2	15.0	13.2	13.2	10.4	0.010	2	SS
MW-5D	585.7	588.47	559.7	559.7	26.0	26.0	10.0	5.0	0.010	2	SS
MW-6S	585.7	588.45	572.2	572.2	13.5	13.5	11.0	10.0	0.010	2	SS
MW-6D	585.7	588.51	558.2	559.2	27.5	26.5	10.0	5.0	0.010	2	SS
MW-7S	584.9	587.78	571.9	573.3	13.0	11.6	12.4	10.0	0.010	2	SS
MW-7D	585.0	588.14	553.5	553.9	31.5	31.1	8.4	4.7	0.010	2	SS
MW-8S	586.5	586.43	572.0	573.9	14.5	12.6	12.6	9.7	0.010	2	SS
MW-8D	586.4	586.09	554.9	555.6	31.5	30.8	9.5	5.0	0.010	2	SS
MW-9S	585.4	588.49	571.4	573.0	14.0	12.4	12.3	9.7	0.010	2	SS
MW-9D	585.7	588.65	554.2	554.2	31.5	31.5	9.3	4.7	0.010	2	SS
MW-10S	585.7	588.58	570.7	572.3	15.0	13.4	13.1	10.0	0.010	2	SS
MW-10D	585.6	588.60	555.6	555.8	30.0	29.8	7.0	4.9	0.010	2	SS
MW-11S	585.0	587.83	571.5	573.6	13.5	11.4	12.8	9.7	0.010	2	SS
MW-11D	585.0	587.98	556.5	557.3	28.5	27.7	9.7	4.7	0.010	2	SS

TABLE 4.2-1 (Cont.)

MONITORING WELL AND PIEZOMETER CONSTRUCTION SUMMARY

WELL	ELEVATION (FT MSL)				DEPTH (FT BGS)		SAND PACK LENGTH (FT)	SCREEN LENGTH (FT)	SLOT SIZE (IN)	WELL DIAMETER (IN)	RISER AND SCREEN MATERIAL
			BOTTOM OF		BOTTOM OF						
	GROUND[1]	RISER[1]	BOREHOLE	WELL	BOREHOLE	WELL					
MW-12S	586.2	586.03	571.2	573.8	15.0	12.4	13.5	9.7	0.010	2	SS
MW-12D	586.2	586.01	552.2	552.5	34.0	33.7	8.4	4.7	0.010	2	SS
MW-13S	587.1	586.95	573.1	573.9	14.0	13.2	12.0	9.9	0.010	2	SS
MW-13D	587.1	586.90	553.1	553.6	34.0	33.5	8.0	5.0	0.010	2	SS
MW-14S	584.1	583.92	570.6	572.4	13.5	11.7	13.3	10.0	0.010	2	SS
MW-14D	584.3	584.05	552.8	553.2	31.5	31.1	8.0	5.0	0.010	2	SS
MW-15S	585.3	585.33	571.3	573.5	14.0	11.8	12.8	10.0	0.010	2	SS
MW-15D	585.5	585.39	556.0	556.3	29.5	29.2	8.5	4.7	0.010	2	SS
P-101[4]	585.0	588.14	571.0	572.9	14.0	12.1	12.5	10.0	0.010	1	PVC
P-102	585.6	588.52	571.6	573.4	14.0	12.2	12.5	10.0	0.010	1	PVC
P-103	586.4	589.44	571.9	573.9	14.5	12.5	13.0	10.0	0.010	2	PVC
P-104	586.0	589.07	572.0	574.0	14.0	12.0	12.5	10.0	0.010	1	PVC
P-105	584.2	583.96	570.2	572.5	14.0	11.7	13.5	10.0	0.010	2	PVC
P-106	586.4	589.60	556.9	557.5	29.5	28.9	27.5	24.3	0.010	2	PVC
P-107	584.9	584.41	569.9	572.4	15.0	12.5	14.0	9.3	0.010	2	PVC
P-108	586.6	589.52	556.6	557.6	30.0	29.0	9.5	5.0	0.010	2	PVC
PW-1	586.4	589.00	553.0	553.0	33.4	33.4	28.9	22.7	0.008	6	SS
W-2A[5]	584.1	586.22	575.6	575.5	8.5	8.6	8.5	5.5	NA	1.25	SS
W-2B[5]	584.1	586.74	564.1	564.2	20.0	19.9	3.0	2.5	NA	1.25	SS
W-2C[5]	584.1	586.80	549.1	552.3	35.0	31.8	8.0	2.5	NA	1.25	SS

TABLE 4.2-1 (Cont.)

MONITORING WELL AND PIEZOMETER CONSTRUCTION SUMMARY

WELL	ELEVATION (FT MSL)				DEPTH (FT BGS)		SAND PACK LENGTH (FT)	SCREEN LENGTH (FT)	SLOT SIZE (IN)	WELL DIAMETER (IN)	RISER AND SCREEN MATERIAL
	GROUND[1]	RISER[1]	BOTTOM OF		BOTTOM OF						
			BOREHOLE	WELL	BOREHOLE	WELL					
W-4A[5]	584.6	586.45	576.1	576.0	8.5	8.6	8.5	5.5	NA	1.25	SS
W-4B[5]	584.5	586.39	564.5	564.9	20.0	19.6	4.0	2.5	NA	1.25	SS
W-4C[5]	584.6	586.41	554.6	558.0	30.0	26.6	7.0	2.5	NA	1.25	SS
W-5[5]	586.2	589.66	577.2	577.2	9.0	9.0	9.0	5.5	NA	1.25	SS
W-6[5]	586.4	589.80	576.4	576.8	10.0	9.6	10.0	5.5	NA	1.25	SS
W-12[6]	583.7	585.81	573.7	576.7	10.0	7.0	8.0	5.0	NA	2	SS
W-13[6]	585.4	587.63	574.4	575.4	11.0	10.0	8.0	5.0	NA	2	SS
L-1[7]	584.7	586.4	466.2	471.2	118.5	113.5	22.0	10.0	0.010	1	PVC
L-2B[7]	583.4	585.4	449.9	458.4	133.5	125.0	23.6	10.0	0.010	1	PVC

NA Not Available
[1] Ground surface and riser elevation data from Barr Engineering Company survey.
[2] Converted to at grade well protection on 9/11/93. Previous riser elevation was 589.17 ft MSL.
[3] Converted to at grade well protection on 9/11/93. Previous riser elevation was 589.06 ft MSL.
[4] Piezometer P-101 was abandoned on 8/31/93.
[5] Well construction data from Warzyn Eng. Inc., 9/20/79, Hydrogeologic Investigation, Outboard Marine Corporation, Waukegan Illinois.
[6] Well construction data from Warzyn Eng. Inc., 7/29/80, Subsurface Investigation, North Ditch Area, Outboard Marine Corporation, Waukegan,Illinois.
[7] Well construction data and elevation data form Canonie Environmental, 3/90, Draft Summary Report, New Slip Soil Investigation, Waukegan Harbor, Illinois.